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ABSTRACT

Proper installations, inspections, operations, maintenance and repairs of wastewater collection, conveyance and treatment facilities have a significant impact on the operation and maintenance costs, and the effectiveness of these facilities. This manual is the second volume of a two-part program designed to provide wastewater collection system operators with the knowledge and skills to effectively operate and maintain collection systems. Originally developed as a part of a home-study course for collection system operators in remote areas, it is now used as a text in college and university classes. This volume contains chapters dealing with: (1) lift stations; (2) equipment maintenance; (3) sewer rehabilitation; (4) safety/survival programs for collection system operators; (5) administration; and (6) organization for system operation and maintenance. Included is a final examination, a glossary of terms, and an index. (TW)

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OPERATION AND MAINTENANCE OF WASTEWATER COLLECTION SYSTEMS

Third Edition
Volume II

A Field Study Training Program

prepared by

California State University, Sacramento
Department of Civil Engineering
Office of Water Programs

in cooperation with
California Water Pollution Control Association

* * *

Kenneth D. Kerri, Project Director
John Brady, Co-Director

* * *

for the

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Office of Water Program Operations
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First Edition, Grant No. T900494 (1976)
1987

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5

PREFACE TO THE THIRD EDITION
VOLUME II

Volume II is a continuation of Volume I. Volume I emphasizes the knowledge and skills needed by new collection system operators and the operators of smaller collection systems. Topics covered in Volume I stress the important role of being a collection system operator and the operator's responsibilities with respect to protecting the community's public health, investment in collection system and wastewater treatment facilities and ultimately the environment in which we live. Volume I discusses the objectives of collection systems, describes collection systems and stresses the importance of following safe procedures at all times. A section of Volume I provides details on the installation and inspection of sewers so operators will know how they are built and what is underground. Major subjects covered include how to inspect old and new collection systems and how to conduct TV inspections and interpret the results. Both hydraulic and mechanical means of cleaning and maintaining sewers, as well as underground repair procedures are covered extensively.

Volume II shifts emphasis from tasks performed by line maintenance crews to the duties of operating and maintaining lift stations, maintenance of equipment and sewer rehabilitation. Topics related to the duties of supervisors are also covered with emphasis on administration and organization of the collection system operation and maintenance activities.

Safety is stressed throughout both Volumes I and II. In Volume II an entire chapter is devoted to safety programs for collection system operators. The safety record to date in the collection system field is dismal. All of us must take responsibility for ourselves and all of our co-workers and do everything possible to eliminate safety hazards and follow safe procedures. None of us want the burden of knowing that we could have prevented an injury to ourselves or to a personal friend.

Regardless of your experience in the collection system profession or the size, age or type of collection system that you operate and maintain, all of the chapters in Volume I and II contain information you need to know to do your job. Every collection system needs operators who know how to operate and maintain the facilities as well as competent administrators to manage the program.

Please refer to Volume I for information on:

1. Objectives of these manuals,
2. Scope of these manuals,
3. Instruction to participants in the home-study course,
4. Uses of these manuals, and
5. Summary of procedures,

1987

KENNETH D. KERRI
JOHN BRADY

6

COURSE OUTLINE

Volume I

CHAPTER	TOPIC	PAGE
1	The Wastewater Collection System Operator	1
2	Why Collection System Operation and Maintenance	13
3	Wastewater Collection Systems	23
4	Safe Procedures	109
5	Inspecting and Testing Collection Systems	175
6	Pipeline Cleaning and Maintenance Methods	255
7	Underground Repair	363
APPENDIX	Final Examination	425
	Collection System Words	431
	Applications of Arithmetic to Collection Systems	471
	Index	511

COURSE OUTLINE

Volume II

CHAPTER	TOPIC	PAGE
8	Lift Stations	1
9	Equipment Maintenance	121
10	Sewer Rehabilitation	235
11	Safety Programs for Collection System Operators	295
12	Administration	315
13	Organization for System Operation and Maintenance	405
APPENDIX	Final Examination	461
	Collection System Words	469
	Index	511

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Third Edition

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CHAPTER 8

LIFT STATIONS

by

Manual Munoz

and

John Brady

Revised by

Rick Arbour

8

TABLE OF CONTENTS

Chapter 8. Lift Stations

Page

OBJECTIVES 5

GLOSSARY 6

LESSON 1

8.1 Purpose of a Lift Station 8

- 8.11 Location 8
- 8.12 Types of Lift Stations 9
  - 8.120 Manhole Used as Wet Well Station 9
  - 8.121 Wet Well Station 9
  - 8.122 Dry Well Station 9
- 8.13 Lift Station Requirements 19

LESSON 2

8.2 Components of a Lift Station 25

- 8.21 Wet Wells 25
  - 8.210 Wet Well Dimensions 25
  - 8.211 Flow Distribution 25
  - 8.212 Operating Levels 25
  - 8.213 Wet Well Access 27
  - 8.214 Wet Well Inlet Channel 27
  - 8.215 Wet Well Safety 27
  - 8.216 Wet Well Hardware 27
  - 8.217 Wet Well Electrical Systems 27
- 8.22 Bar Racks 27
- 8.23 Dry Wells 28
- 8.24 Electrical System 28
  - 8.240 Typical Systems 28
  - 8.241 Power Transformers 28
  - 8.242 Metering 28
  - 8.243 Main Disconnect 28

8.244 Transfer Switch 28
8.245 Motor Control Center 28
8.246 110-Volt/220-Volt Loads 31
8.247 Supervisory Controls 31
8.25 Motors 31
8.26 Supervisory Controls 34
8.260 Float Controllers 35
8.261 Electrode Controllers 38
8.262 Enclosed-Electrode Controllers 38
8.263 Pressure-Sensing Controllers 38
8.264 Microprocessor-Based Supervisory Controllers 42
8.265 Additional Reading 42
8.27 Pumps 42
8.270 Centrifugal Pumps 42
8.271 Pump Layouts 44
8.272 Pump Components 44
8.273 How to Read and Understand a Centrifugal Pump Selection Curve 54
8.274 Sump Pump 56
8.28 Lift Station Valves 56
8.280 Gate Valves 56
8.281 Plug Valves 59
8.282 Check Valves 59
8.29 Ventilation and Auxiliary Equipment 59

LESSON 3

8.3 The Newly Constructed Lift Station 63
8.31 Examination of Prints 63
8.32 Reading Specifications 63
8.33 Preliminary Inspection of a New Lift Station 64
8.34 Pump Station Calibration 64
8.35 Inspection of a Lift Station 65
8.36 Operational Inspection 69

LESSON 4

8.4 Operation of Wastewater Lift Stations 71
8.41 Lift Station Visits by Operators 72
8.42 Frequency of Visits to Lift Stations 72
8.43 Essential Tasks During Lift Station Visits 77
8.430 Station Sign-in Log 77
8.431 The Station Book 77
8.432 Operation and Maintenance Duties 79
8.433 Responding to Station Alarms 79
8.434 Typical Lift Station Problems 82

LESSON 5

8.5 Lift Station Maintenance 83
8.51 Scheduling Maintenance 84
8.510 Recommendations of Equipment Manufacturers 84
8.511 Lift Station Requirements 84
8.512 Knowledge Gained from Experience 84
8.52 The Actual Maintenance Schedule 85
8.520 Crew Notification of Required Maintenance 85
8.521 Recording Completed Work 85
8.6 Recordkeeping 85
8.61 Filing of Records 85
8.62 Cost Records 85
8.63 Station Identification Number 87
8.64 Other Records 87
8.640 Preventive Maintenance Schedule for Lift Stations 87
8.641 Unscheduled Work Order Requests 87
8.642 Modifications Made to the Station or Force Main. 87
8.643 Written Reports 88
8.644 Operational Data 88
8.7 Summary 88
SUGGESTED ANSWERS 89
OBJECTIVE TEST 92
SUPPLEMENT — A PREVENTIVE MAINTENANCE PROGRAM 95

OBJECTIVES

Chapter 8. LIFT STATIONS

After completion of Chapter 8 you should be able to do the following:

1. Determine locations of lift stations,
2. Describe requirements of a lift station,
3. Discuss components of a lift station,
4. Indicate advantages and disadvantages of the different types of controllers,
5. Review lift station prints and specifications,
6. Inspect a new lift station,
7. Keep lift station operating as intended,
8. Determine frequency of visits to a lift station,
9. Perform necessary lift station maintenance tasks, and
10. Prepare record forms for a lift station, complete and file them.

LOCATION
PRINTS
SPECS
RECORD FILES
MAINTENANCE
VISITS

GLOSSARY

CAVITATION (CAV-i-TAY-shun) CAVITATION

The formation and collapse of a gas pocket or bubble on the blade of an impeller. The collapse of this gas pocket or bubble drives water into the impeller with a terrific force that can cause pitting on the impeller surface.

COMMINUTOR (com-mih-NEW-ter) COMMINUTOR

A device used to reduce the size of the solid chunks in wastewater by shredding (comminuting). The shredding action can be visualized if you imagine many scissors cutting to shreds all of the large solids in the wastewater.

DISCHARGE HEAD DISCHARGE HEAD

The pressure (in feet or pounds per square inch (psi)) on the discharge side of a pump. The pressure can be measured from the center line of the pump to the hydraulic grade line of the water in the discharge pipe.

DRY PIT DRY PIT

See DRY WELL.

DRY WELL DRY WELL

A dry room or compartment in a lift station, near or below the water level, where the pumps are located.

DYNAMIC HEAD DYNAMIC HEAD

When a pump is operating, the vertical distance (in feet) from a point to the energy grade lines. Also see TOTAL DYNAMIC HEAD, STATIC HEAD, and ENERGY GRADE LINE.

ELECTROLYTE SOLUTION (e-LECK-tro-light) ELECTROLYTE SOLUTION

A special solution that is capable of conducting electricity.

ENERGY GRADE LINE (E.G.L.) ENERGY GRADE LINE

A line that represents the elevation of energy head (in feet) of water flowing in a pipe, conduit or channel. The line is drawn above the hydraulic grade line a distance equal to the velocity head of the water flowing at each section or point along the pipe or channel.

FORCE MAIN FORCE MAIN

A pipe that carries wastewater under pressure from the discharge side of a pump to a point of gravity flow downstream.

HEAD HEAD

A term used to describe the height or energy of water above a point. A head of water may be measured in either height (feet) or pressure (pounds per square inch (psi)). Also see DISCHARGE HEAD, DYNAMIC HEAD, STATIC HEAD, SUCTION HEAD, SUCTION LIFT and VELOCITY HEAD.

HYDRAULIC GRADE LINE (H.G.L.) HYDRAULIC GRADE LINE

The surface or profile of water flowing in an open channel or a pipe flowing partially full. If a pipe is under pressure, the hydraulic grade line is at the level water would rise to in a small tube connected to the pipe. To reduce the release of odors from sewers, the water surface or hydraulic grade line should be kept as smooth as possible.

IMPELLER IMPELLER

A rotating set of vanes in a pump designed to pump or lift water.

LIFT STATION LIFT STATION

A wastewater pumping station that lifts the wastewater to a higher elevation when the continuing of the sewer at reasonable slopes would involve excessive depths of trench. Also an installation of pumps that raise wastewater from areas too low to drain into available sewers. These stations may be equipped with air-operated ejectors or centrifugal pumps. Sometimes called a PUMP STATION, but this term is usually reserved for a similar type of facility that is discharging into a long FORCE MAIN, while a lift station has a discharge line or force main only up to the downstream gravity sewer. Throughout this manual when we refer to lift stations, we intend to include pump stations.

LUBRIFLUSHING (LOOB-rah-FLUSH-ing) LUBRIFLUSHING

A method of lubricating bearings with grease. Remove the relief plug and apply the proper lubricant to the bearing at the lubrication fitting. Run the pump to expel excess lubricant.

PNEUMATIC EJECTOR (new-MAT-tik ee-JECK-tor) PNEUMATIC EJECTOR

A device for raising wastewater, sludge or other liquid by alternately admitting it through an inward-swinging check valve into the bottom of an airtight pot and then discharging it through an outward-swinging check valve by admitting compressed air to the pot above the wastewater.

PUMP PIT PUMP PIT

A dry well, chamber or room below ground level in which a pump is located.

STATIC HEAD STATIC HEAD

When water is not moving, the vertical distance (in feet) from a point to the water surface is the static head. Also see DYNAMIC HEAD.

STILLING WELL STILLING WELL

A pipe, chamber, or compartment with a relatively small inlet or inlets connected to a main body of water, such as water in a wet well. The purpose of a stilling well is to dampen waves or surges while allowing the water level within the well to rise and fall with the major fluctuations of the main body of water. Stilling wells are used with water flow- and depth-measuring devices to improve the accuracy of measurement.

SUCTION HEAD SUCTION HEAD

The *POSITIVE* pressure (in feet or pounds per square inch (psi)) on the suction side of a pump. The pressure can be measured from the center line of the pump *UP TO* the elevation of the hydraulic grade line on the suction side of the pump.

SUCTION LIFT SUCTION LIFT

The *NEGATIVE* pressure (in feet or inches of mercury vacuum) on the suction side of a pump. The pressure can be measured from the center line of the pump *DOWN TO* the elevation of the hydraulic grade line on the suction side of the pump.

TOTAL DYNAMIC HEAD (T.D.H.) TOTAL DYNAMIC HEAD

When a pump is lifting or pumping water, the vertical distance (in feet) from the elevation of the energy grade line on the suction side of the pump to the elevation of the energy grade line on the discharge side of the pump.

VELOCITY HEAD VELOCITY HEAD

A vertical height (in feet) equal to the square of the velocity of flowing water divided by twice the acceleration due to gravity ($V^2/2g$).

VOLUTE (vol-LOOT) VOLUTE

The spiral-shaped casing surrounding a pump impeller that collects the water discharged by the impeller.

WATER HAMMER WATER HAMMER

The sound like someone hammering on a pipe that occurs when a valve is opened or closed very rapidly. When a valve position is changed quickly, the water pressure in a pipe will increase and decrease back and forth very quickly. This rise and fall in pressures can do serious damage to the system.

WET PIT WET PIT

See WET WELL.

WET WELL WET WELL

A compartment or room in which wastewater is collected, and to which the suction pipe of a pump may be connected. Also, a submersible pump may be located in a wet well.

CHAPTER 8. LIFT STATIONS

(Lesson 1 of 5 Lessons)

8.1 PURPOSE OF LIFT STATIONS

Lift stations are used to lift or raise wastewater or storm water from a lower elevation to a higher elevation. Lifting of the wastewater is accomplished by centrifugal pumps or air operated ejectors. The term *LIFT STATION* usually refers to a wastewater facility with a relatively short discharge line up to the downstream gravity sewer. A *PUMP STATION* commonly is a similar type of facility that is discharging into a long *FORCE MAIN.*[1] Throughout this manual when we refer to lift stations, we intend to include pump stations.

In many areas regional agencies are being created to serve more than one community. As a result, lift stations and force mains tend to be larger and the pumps can range in size up to several hundred horsepower and the force mains can be several miles long.

Lift stations represent a major capital expenditure for an agency or community and they require an adequate budget to operate and maintain them properly. Failures of lift stations and force mains can have a significant impact on the environment when raw wastewater is discharged over land or into lakes, streams, or rivers. Backups into private residences caused by a lift station failure can easily cost thousands of dollars to clean up, replace, and repair damaged homes or businesses. Significant lift station failures make headlines in newspapers and tarnish the image of your collection system agency.

Collection system operators, therefore, play a vital role in preventing catastrophic failures affecting the community. Because pump stations contain complex electrical, mechanical, and hydraulic systems, collection systems operators must have a wide range of training to properly operate and maintain them. This obviously requires a high level of knowledge, skills, and professionalism by all operators.

In many agencies today, collection system operators begin participation at the design stage of new lift stations because of their knowledge and experience on various types of lift stations. Operators can help engineers produce designs which result in improved maintenance and operation of lift stations and lower operating costs while minimizing bypasses and backups.

8.11 Location

Location and design of lift stations depend on economic factors that are analyzed by the design engineer. Lift stations are installed at low points in the collection system at the end of gravity sewers where the following conditions exist:

1. Excavation costs to maintain gravity flow and sufficient velocity become excessive,
2. Soil stability is unsuitable for trenching,
3. Groundwater table is too high for installing deep sewers, and
4. Present wastewater flows are not sufficient to justify extension of large trunk sewers and a lift station offers an economical short-term solution.

Other factors that influence the location of lift stations include the location of other utilities and also the location of surface and overhead structures (buildings and transit systems).

Lift station pumps are designed to move the wastewater with a minimum of energy consumption. The pumps are selected to provide a flow as continuous or constant as possible to minimize surges of wastewater in the downstream sewer and the wastewater treatment plant. Consideration also must be given to installing pumps that require a minimum of maintenance.

Appearance of lift station buildings and grounds should blend in with the surrounding environment. Odors must be controlled and the noise must be kept to a minimum to prevent the lift station from being a nuisance to nearby neighbors.

Safety of the operators involved in operating and maintaining the lift station must be considered, as well as the safety of the public. If chemicals are added to the wastewater at the lift station, care must be exercised when storing, handling, and applying these chemicals.

---

[1] *Force Main. A pipe that carries wastewater under pressure from the discharge side of a pump to a point of gravity flow downstream.*

Collection system operators should have easy access to the lift station during all types of weather conditions so the station can be properly operated and maintained at all times. Utilities required to operate the station must be readily available.

Reliability is the most important requirement of a lift station. Pumps or ejectors, controls, and the maintenance program must be designed to minimize the chances of failures to prevent the flooding of homes and streets.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 89.

8.1A How is wastewater raised or lifted in a lift or pump station?

8.1B What factors influence the location of lift stations?

8.1C What are the two major safety items that must be considered around a lift station?

8.12 Types of Lift Stations

Wastewater lift stations may be constructed in various sizes and shapes depending upon the volume of wastewater or storm water to be handled, the elevation water must be lifted, and the distance water must be pumped before the water returns to flowing in a gravity system. The lift station may range from a standard manhole equipped with a submersible or other wet well type pump, to a factory prefabricated package station, or to an elaborately designed and constructed station capable of pumping large volumes of wastewater. When larger stations are constructed and require a continuous operational staff, they are often referred to as pumping plants.

Stations may be classified as wet well or dry well installations, depending on the locations of the pumping units.

8.120 Manhole Used as Wet Well Station (Figure 8.1)

Precast concrete manhole sections with submersible pumps have been used as lift stations to serve smaller communities. The lift station shown in Figure 8.1 has guide bars made of two-inch pipe which allow the pump to be removed from the top of the manhole by pulling the pump up the guide bars. When the pump is lowered, a flanged, gasketed connection seals the pump to the discharge. The weight of the pump keeps it in place and there are no bolts to remove. Therefore, an operator does not need to enter the wet well to remove or install the pump. Figure 8.2 contains the details of a submersible pump and the connection to the discharge pipe or force main.

8.121 Wet Well Station

Large wet well stations today can provide capacities up to 25,000 GPM at discharge heads of 80 to 100 feet. These large stations are in wide use and two different types of configurations are frequently constructed:

1. Those that use larger submersible pumps, and
2. Those that use an above-ground pump station. In this type, a fiberglass enclosure usually sits on top of the wet well with the suction pipe extending down into the wet well (this is known as a pump which pulls a suction lift).

Because the above-ground station must "lift" the water up to the pump suction, the above-ground type stations use self-priming centrifugal pumps. The maximum pump size is usually six or eight inches, whereas the submersible pump can be as large as twenty-four inches. Depending on the pump size and number of pumps, the wet well could be constructed of precast concrete manhole sections, rectangular box culvert sections, or poured-in-place concrete structures for the larger pumps. Wet well installations typically have limited access to the pumping equipment. If anything goes wrong, they can be difficult to repair.

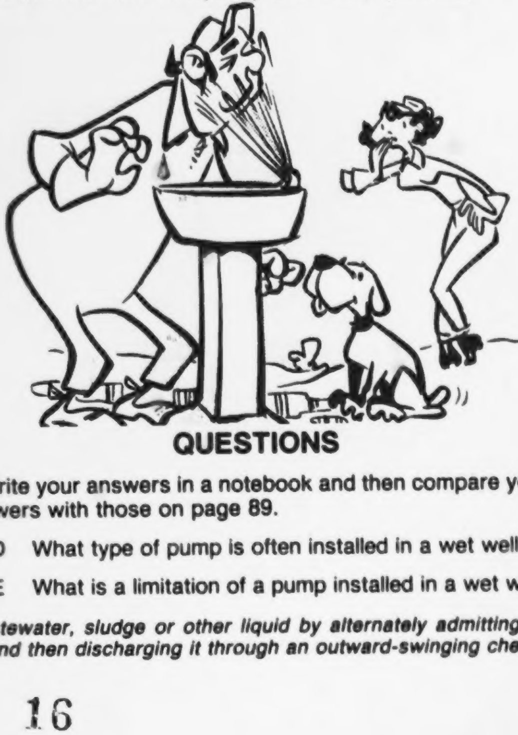
Figure 8.3 illustrates a typical duplex (two pumps) submersible pumping station and its major components while Figure 8.4 illustrates an above-ground duplex pump station with a fiberglass-reinforced plastic enclosure.

Equipment located in the wet well should be minimized, including suction and discharge valves, check valves, or other equipment which requires routine, periodic maintenance. This equipment can be located in small equipment manholes located adjacent to the wet well to make accessibility and maintenance much easier for the operator.

8.122 Dry Well Station

Dry well stations are another common type of lift station found in the collection system. This type of station isolates the pumps, motors, electrical control and auxiliary equipment from the wet well in a separate dry well. This feature provides a cleaner and safer environment for operation and maintenance personnel. These stations will range in size from smaller prefabricated pump stations constructed of steel or fiberglass that come already assembled from the factory (Figure 8.5) to much larger concrete cast-in-place stations which may or may not include a building to house the equipment, depending on environmental conditions (Figures 8.6, 8.7 and 8.8).

The third type of wet well/dry well lift station that has been used in smaller areas is the *PNEUMATIC EJECTOR*[2] which uses air pressure to eject the wastewater; however, this type of station is limited in capacity and size (Figure 8.9).



QUESTIONS

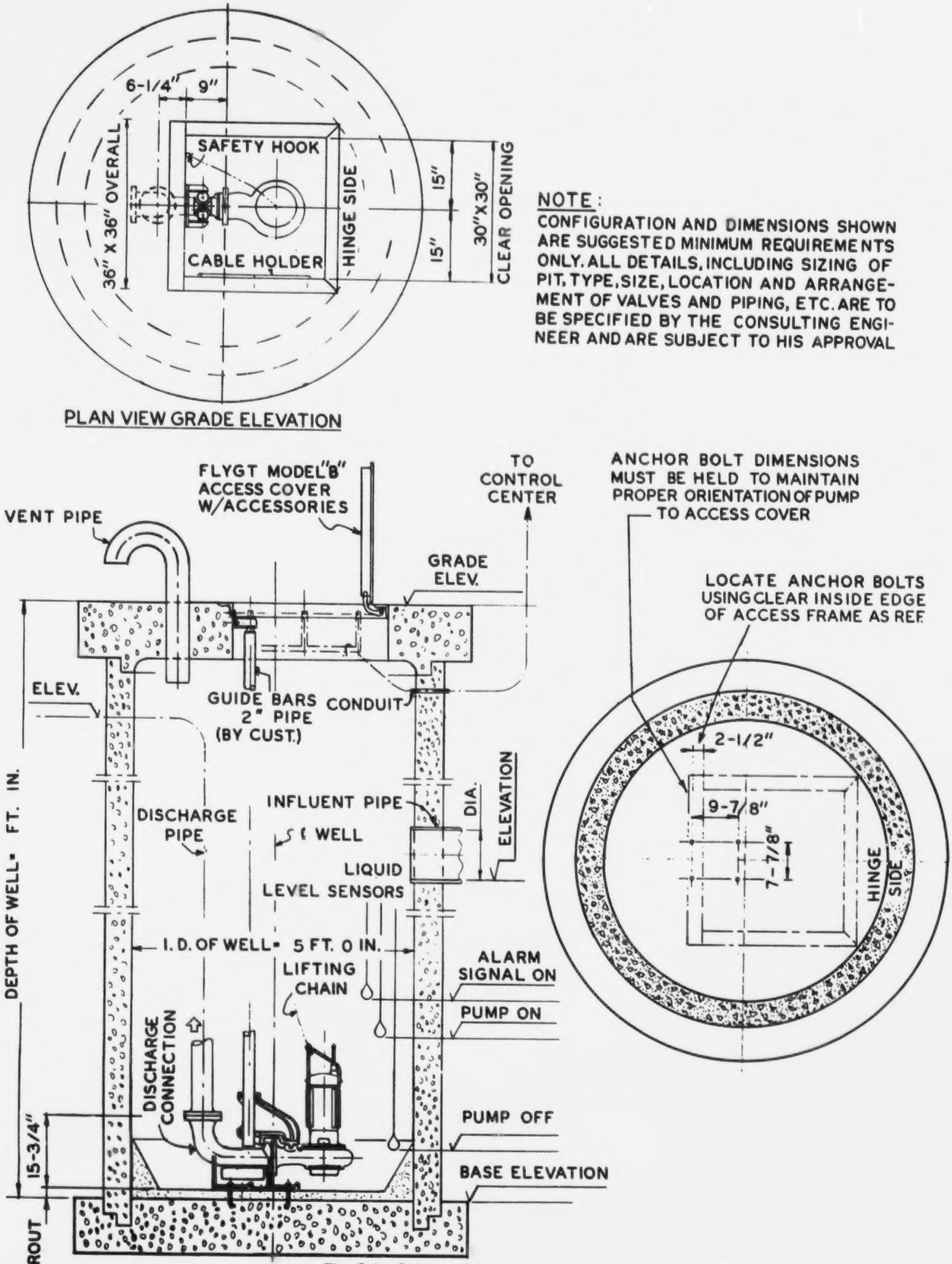
Write your answers in a notebook and then compare your answers with those on page 89.

8.1D What type of pump is often installed in a wet well?

8.1E What is a limitation of a pump installed in a wet well?

---

[2] Pneumatic Ejector (new-MAT-tik ee-JECK-tor). A device for raising wastewater, sludge or other liquid by alternately admitting it through an inward-swinging check valve into the bottom of an airtight pot and then discharging it through an outward-swinging check valve by admitting compressed air to the pot above the wastewater.


6-1/4"
9"
SAFETY HOOK
36" X 36" OVERALL
HINGE SIDE
CABLE HOLDER
15"
15"
30"X30" CLEAR OPENING
PLAN VIEW GRADE ELEVATION
FLYGT MODEL "B" ACCESS COVER W/ACCESSORIES
TO CONTROL CENTER
VENT PIPE
GRADE ELEV.
ELEV.
GUIDE BARS 2" PIPE (BY CUST.)
CONDUIT
DEPTH OF WELL - FT. IN.
INFLUENT PIPE
DIA.
ELEVATION
DISCHARGE PIPE
℄ WELL
LIQUID LEVEL SENSORS
I. D. OF WELL - 5 FT. 0 IN.
LIFTING CHAIN
ALARM SIGNAL ON
PUMP ON
DISCHARGE CONNECTION
PUMP OFF
15-3/4"
BASE ELEVATION
GROUT
ANCHOR BOLT DIMENSIONS MUST BE HELD TO MAINTAIN PROPER ORIENTATION OF PUMP TO ACCESS COVER
LOCATE ANCHOR BOLTS USING CLEAR INSIDE EDGE OF ACCESS FRAME AS REF.
2-1/2"
9-7/8"
7-7/8"
HINGE SIDE

NOTE:
CONFIGURATION AND DIMENSIONS SHOWN ARE SUGGESTED MINIMUM REQUIREMENTS ONLY. ALL DETAILS, INCLUDING SIZING OF PIT, TYPE, SIZE, LOCATION AND ARRANGEMENT OF VALVES AND PIPING, ETC. ARE TO BE SPECIFIED BY THE CONSULTING ENGINEER AND ARE SUBJECT TO HIS APPROVAL

Fig. 8.1 Submersible pump in wet well

(Courtesy of Flygt)

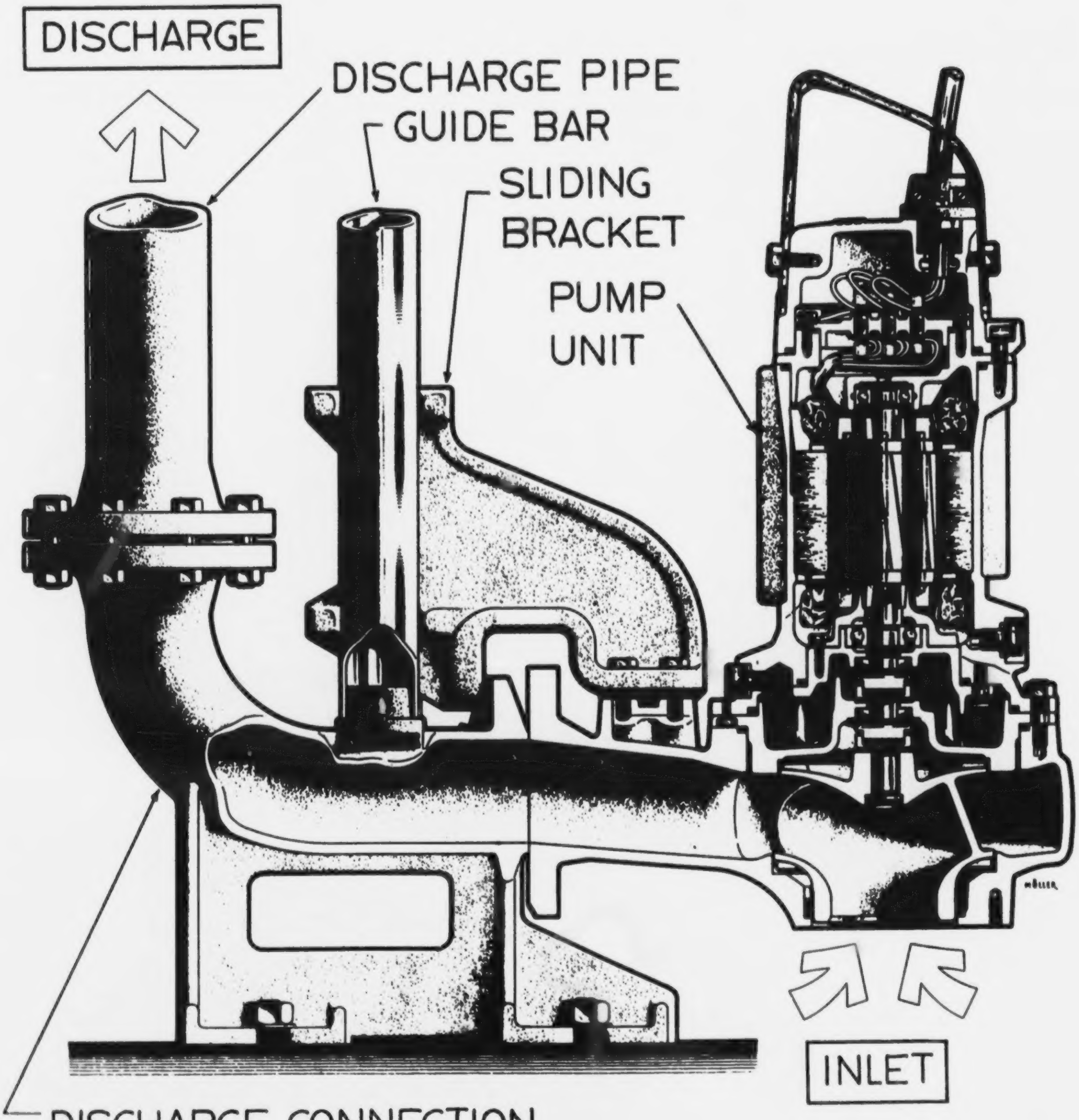
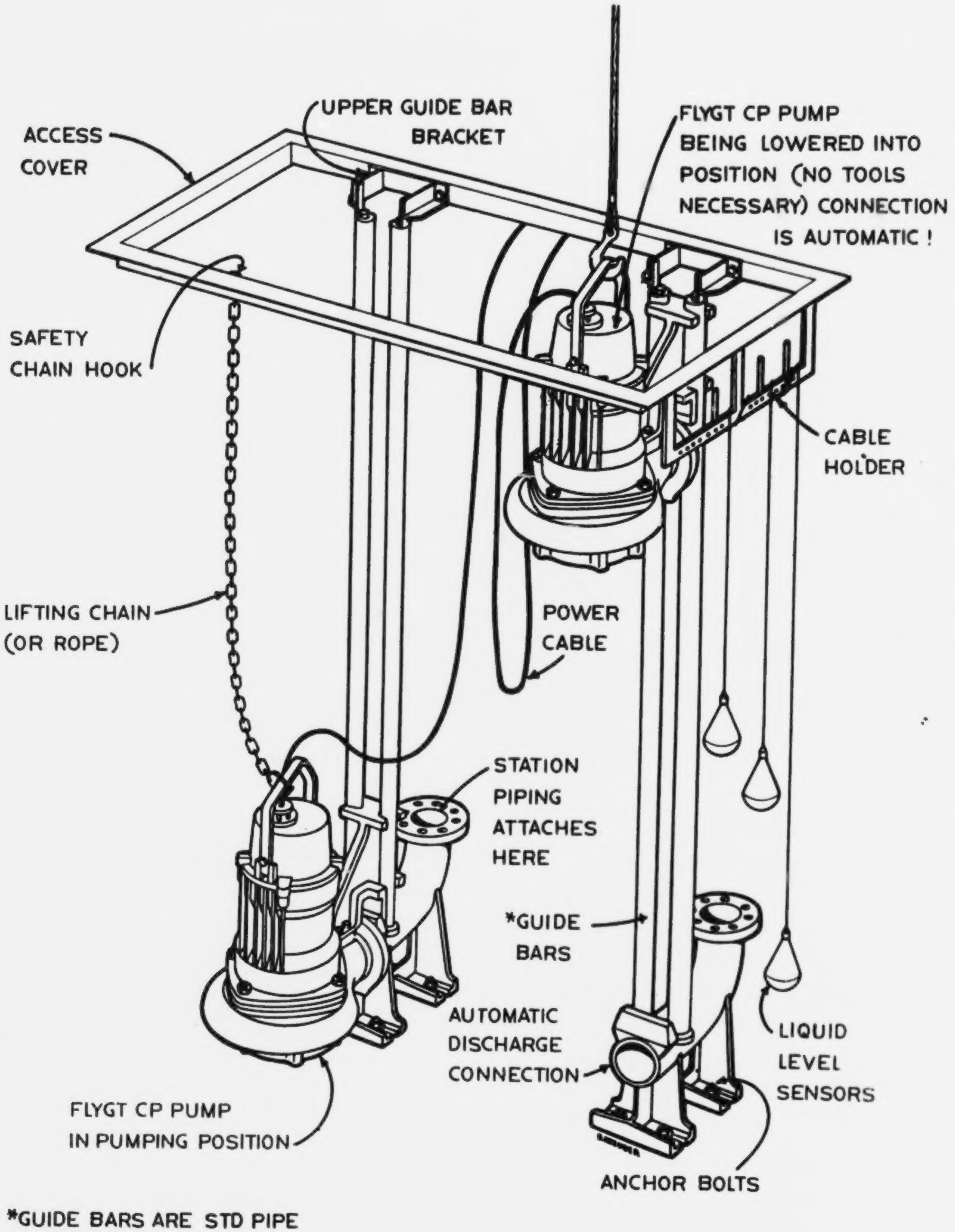

DISCHARGE
DISCHARGE PIPE
GUIDE BAR
SLIDING BRACKET
PUMP UNIT
INLET
DISCHARGE CONNECTION (BOLTED TO SUMP FLOOR)

Fig. 8.2 Details of pump with automatic discharge connection
(Courtesy of Flygt)


UPPER GUIDE BAR BRACKET
ACCESS COVER
FLYGT CP PUMP BEING LOWERED INTO POSITION (NO TOOLS NECESSARY) CONNECTION IS AUTOMATIC !
SAFETY CHAIN HOOK
CABLE HOLDER
LIFTING CHAIN (OR ROPE)
POWER CABLE
STATION PIPING ATTACHES HERE
*GUIDE BARS
AUTOMATIC DISCHARGE CONNECTION
LIQUID LEVEL SENSORS
FLYGT CP PUMP IN PUMPING POSITION
ANCHOR BOLTS

*GUIDE BARS ARE STD PIPE

Fig. 8.3 Duplex submersible pumping station
(Courtesy of Flygt)

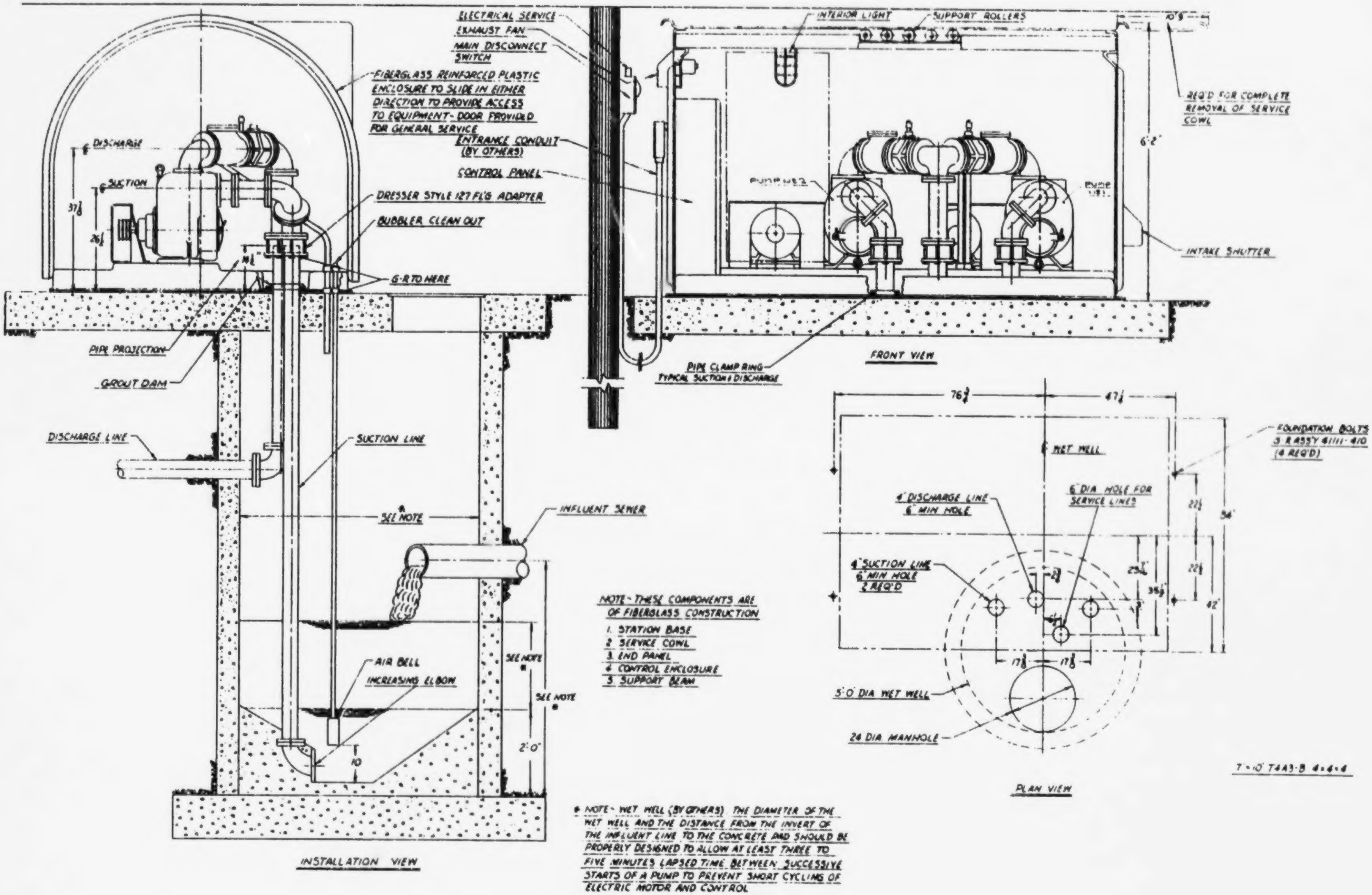

ELECTRICAL SERVICE
EXHAUST FAN
MAIN DISCONNECT SWITCH
FIBERGLASS REINFORCED PLASTIC ENCLOSURE TO SLIDE IN EITHER DIRECTION TO PROVIDE ACCESS TO EQUIPMENT - DOOR PROVIDED FOR GENERAL SERVICE
ENTRANCE CONDUIT (BY OTHERS)
CONTROL PANEL
DRESSER STYLE 127 FL'G ADAPTER
BUBBLER CLEAN OUT
G.R. TO HERE
℄ DISCHARGE
℄ SUCTION
37⅞
26⅛
1¼
PIPE PROJECTION
GROUT DAM
DISCHARGE LINE
SUCTION LINE
SEE NOTE
INFLUENT SEWER
AIR BELL
INCREASING ELBOW
SEE NOTE
SEE NOTE
2'-0"
10
INSTALLATION VIEW
INTERIOR LIGHT
SUPPORT ROLLERS
10'5
REQ'D FOR COMPLETE REMOVAL OF SERVICE COWL
6'-2"
PUMP NO. 2
PUMP NO. 1
INTAKE SHUTTER
PIPE CLAMP RING TYPICAL SUCTION & DISCHARGE
FRONT VIEW
NOTE - THESE COMPONENTS ARE OF FIBERGLASS CONSTRUCTION
1. STATION BASE
2 SERVICE COWL
3 END PANEL
4 CONTROL ENCLOSURE
3 SUPPORT BEAM
76¾
47¼
℄ WET WELL
FOUNDATION BOLTS 3 R ASS'Y 41111-410 (4 REQ'D)
4" DISCHARGE LINE 6" MIN HOLE
6" DIA HOLE FOR SERVICE LINES
4" SUCTION LINE 6" MIN HOLE 2 REQ'D
22½
22½
54"
42"
25¾"
35¾"
2⅞
17⅞
17⅞
5'-0" DIA WET WELL
24 DIA MANHOLE
7'-10" T4A3-B 4-4-4
PLAN VIEW
* NOTE - WET WELL (BY OTHERS) THE DIAMETER OF THE WET WELL AND THE DISTANCE FROM THE INVERT OF THE INFLUENT LINE TO THE CONCRETE PAD SHOULD BE PROPERLY DESIGNED TO ALLOW AT LEAST THREE TO FIVE MINUTES LAPSED TIME BETWEEN SUCCESSIVE STARTS OF A PUMP TO PREVENT SHORT CYCLING OF ELECTRIC MOTOR AND CONTROL

Fig. 8.4 Above-ground duplex pump station with a fiberglass-reinforced plastic enclosure

(Courtesy of The Gorman-Rupp Co.)

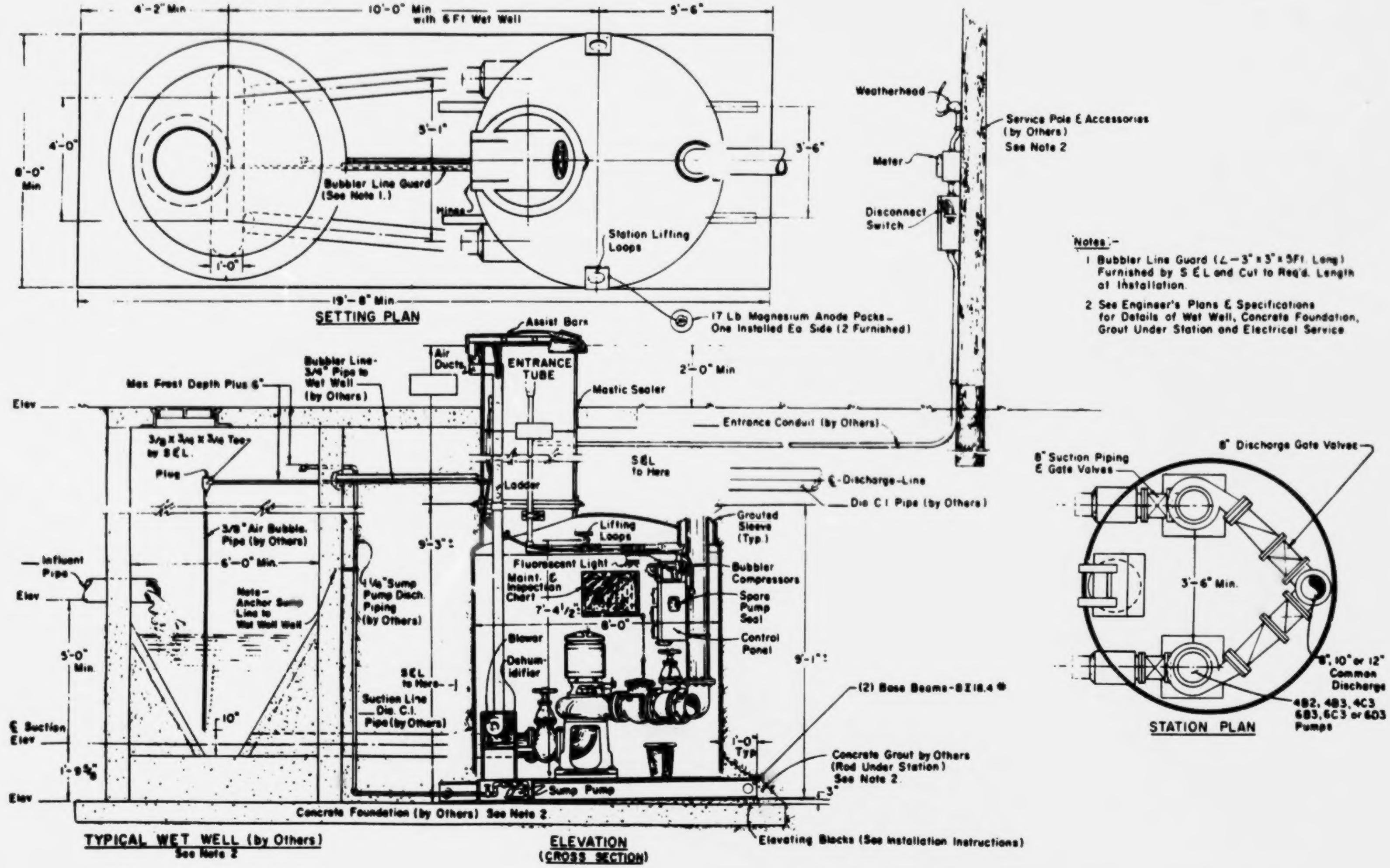

4'-2" Min
10'-0" Min with 6 Ft Wet Well
5'-6"
8'-0" Min
4'-0"
5'-1"
3'-6"
1'-0"
19'-8" Min
Bubbler Line Guard (See Note 1.)
Hinge
Station Lifting Loops
SETTING PLAN
17 Lb Magnesium Anode Packs – One Installed Ea Side (2 Furnished)
Weatherhead
Service Pole & Accessories (by Others) See Note 2
Meter
Disconnect Switch
Notes:–
1 Bubbler Line Guard (∠–3" x 3" x 5Ft. Long) Furnished by S E L and Cut to Req'd. Length at Installation.
2 See Engineer's Plans & Specifications for Details of Wet Well, Concrete Foundation, Grout Under Station and Electrical Service
Assist Bars
Air Ducts
ENTRANCE TUBE
Mastic Sealer
2'–0" Min
Bubbler Line-3/4" Pipe to Wet Well (by Others)
Max Frost Depth Plus 6"
Elev
Entrance Conduit (by Others)
3/8 x 3/8 x 3/8 Tee by S E L.
Plug
SEL to Here
℄-Discharge-Line
Dia C I Pipe (by Others)
Ladder
3/8" Air Bubble Pipe (by Others)
9'-3"
Lifting Loops
Grouted Sleeve (Typ.)
Influent Pipe
6'–0" Min.
Fluorescent Light
Bubbler Compressors
Elev
Note – Anchor Sump Line to Wet Well Wall
1 1/4" Sump Pump Disch. Piping (by Others)
Maint. & Inspection Chart
7'-4 1/2"
8'-0"
Spare Pump Seal
Control Panel
5'-0" Min.
Blower
Dehumidifier
SEL to Here
9'-1"
(2) Base Beams-8 I 18.4 #
Suction Line Dia. C.I. Pipe (by Others)
10"
℄ Suction Elev
1'-0" Typ
1'-9 3/8"
Concrete Grout by Others (Rod Under Station) See Note 2.
Elev
Sump Pump
3"
Concrete Foundation (by Others) See Note 2.
TYPICAL WET WELL (by Others) See Note 2
ELEVATION (CROSS SECTION)
Elevating Blocks (See Installation Instructions)
8" Suction Piping & Gate Valves
8" Discharge Gate Valves
3'-6" Min.
8", 10" or 12" Common Discharge
4B2, 4B3, 4C3 6B3, 6C3 or 6D3 Pumps
STATION PLAN

Fig. 8.5 Prefabricated factory lift station

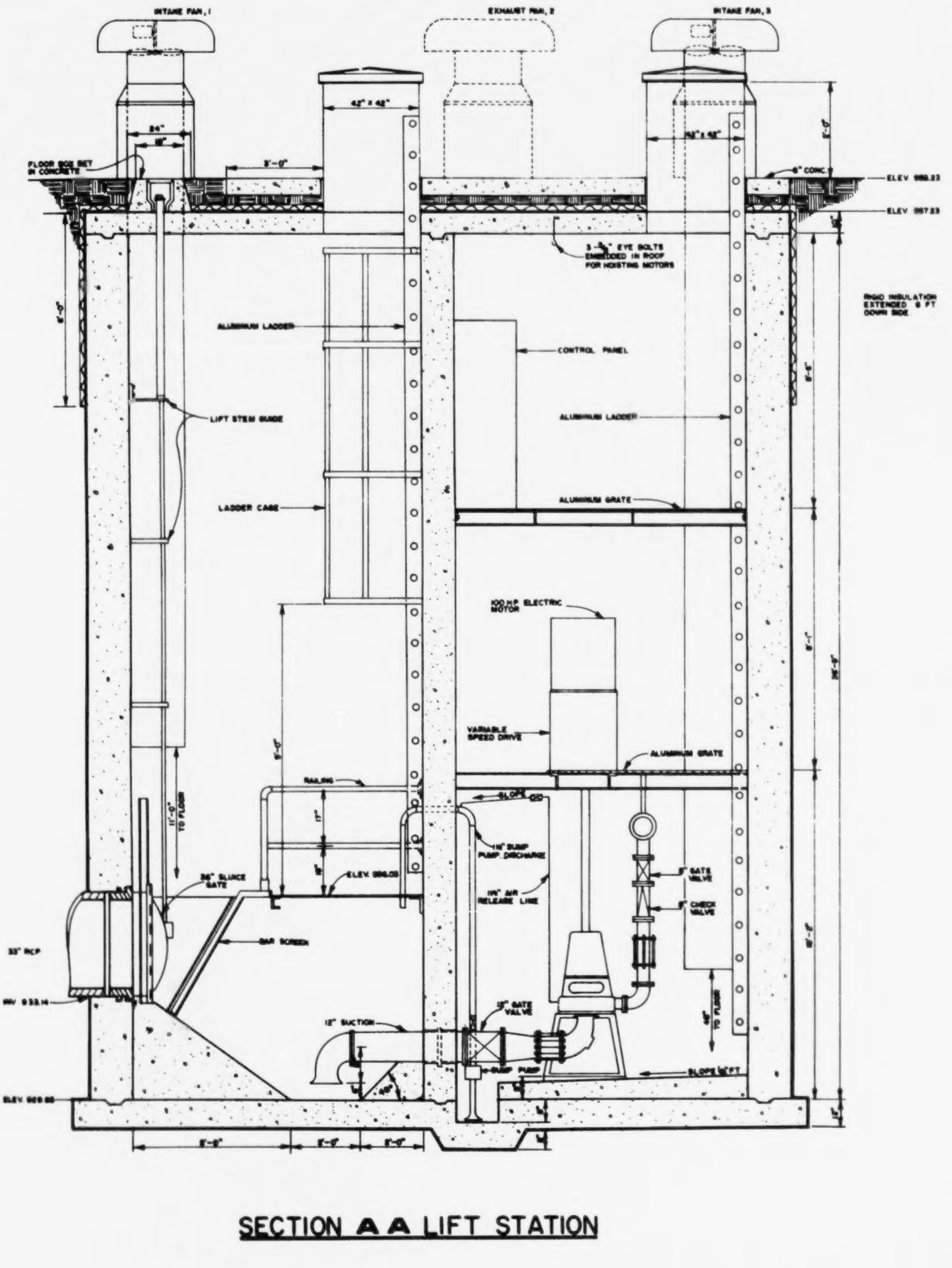
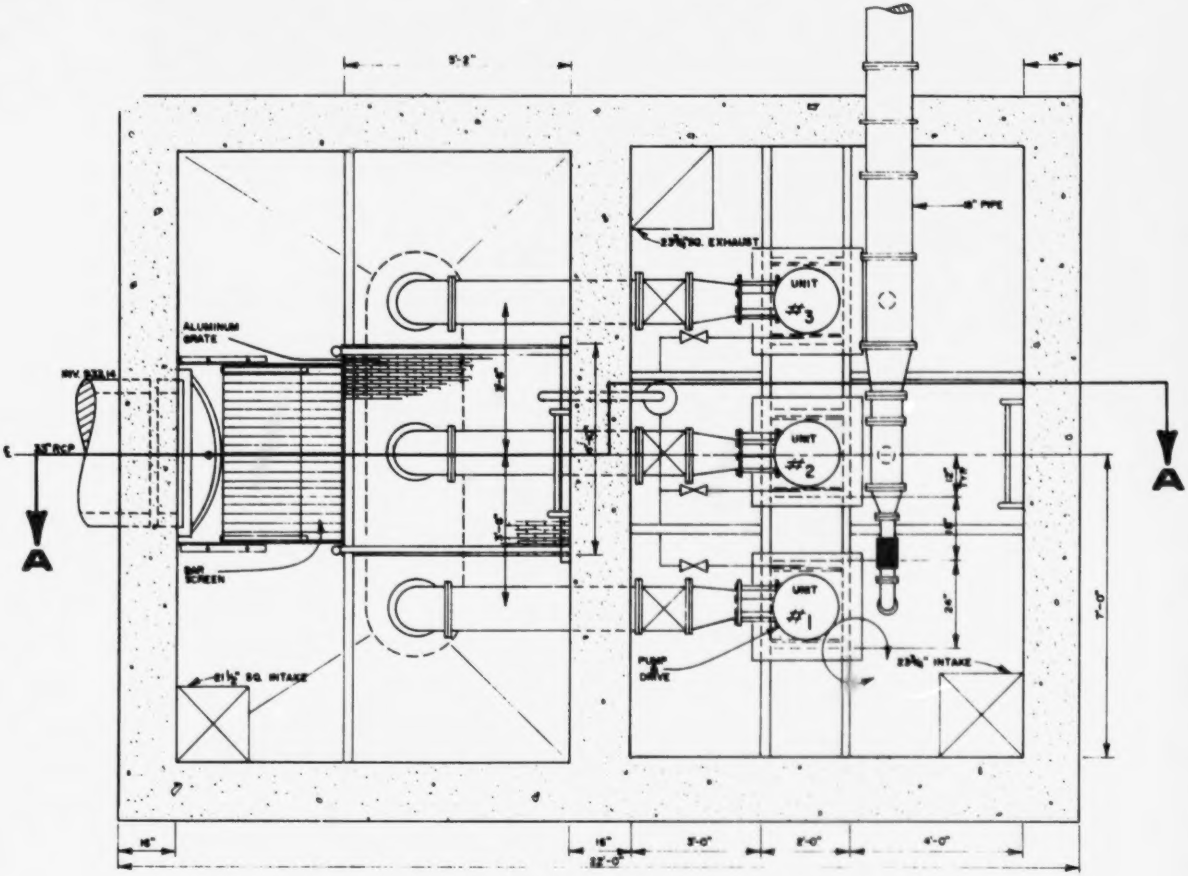

INTAKE FAN, 1
EXHAUST FAN, 2
INTAKE FAN, 3
42" x 42"
24"
18"
3'-0"
42" x 42"
6'-0"
FLOOR BOX SET IN CONCRETE
6" CONC.
ELEV 959.23
ELEV 957.23
3-¾" EYE BOLTS EMBEDDED IN ROOF FOR HOISTING MOTORS
RIGID INSULATION EXTENDED 6 FT DOWN SIDE
6'-0"
ALUMINUM LADDER
CONTROL PANEL
LIFT STEM GUIDE
ALUMINUM LADDER
8'-6"
ALUMINUM GRATE
LADDER CAGE
100 H.P. ELECTRIC MOTOR
8'-1"
26'-9"
9'-0"
VARIABLE SPEED DRIVE
ALUMINUM GRATE
RAILING
SLOPE
17"
11'-0" TO FLOOR
1½" SUMP PUMP DISCHARGE
8" GATE VALVE
8" CHECK VALVE
36" SLUICE GATE
ELEV. 936.00
1½" AIR RELEASE LINE
BAR SCREEN
33" RCP
10'-8"
INV 933.14
4'-6" TO FLOOR
12" GATE VALVE
12" SUCTION
SUMP PUMP
SLOPE ¼" FT
45°
ELEV 929.80
2'-6"
2'-0"
2'-0"
1'-6"
SECTION A A LIFT STATION

Fig. 8.6 Section of cast-in-place lift station



5'-2"
16"
18" PIPE
23 5/8" SQ. EXHAUST
UNIT #3
UNIT #2
UNIT #1
ALUMINUM GRATE
INV. 832.14
33" RCP
A
A
BAR SCREEN
21 1/2" SQ. INTAKE
PUMP & DRIVE
23 5/8" INTAKE
24"
18"
12"
7'-0"
16"
16"
3'-0"
2'-0"
4'-0"
22'-0"

LIFT STATION PLAN

Fig. 8.7 Plan view of Figure 8.6, cast-in-place lift station

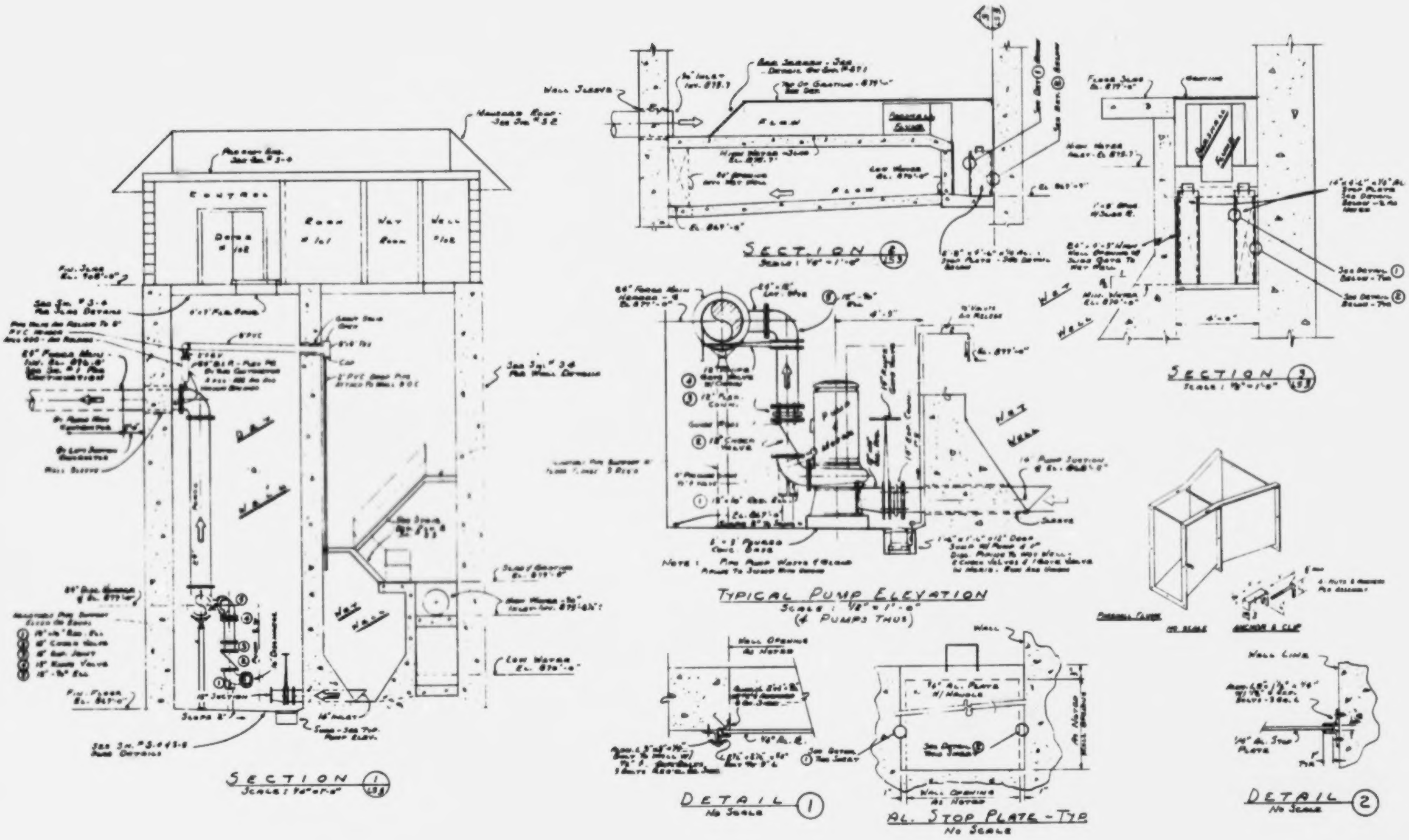

CONTROL ROOM
DRY WELL
WET WELL
FLOW
SECTION 1
SCALE: 1/4"=1'-0"
SECTION 2
SCALE: 1/4"=1'-0"
SECTION 3
SCALE: 1/4"=1'-0"
TYPICAL PUMP ELEVATION
SCALE: 1/2"=1'-0"
(4 PUMPS THUS)
DETAIL 1
NO SCALE
AL. STOP PLATE - TYP
NO SCALE
DETAIL 2
NO SCALE
WALL LINE
WALL OPENING AS NOTED

Fig. 8.8 Cast-in-place lift station with an above-ground structure

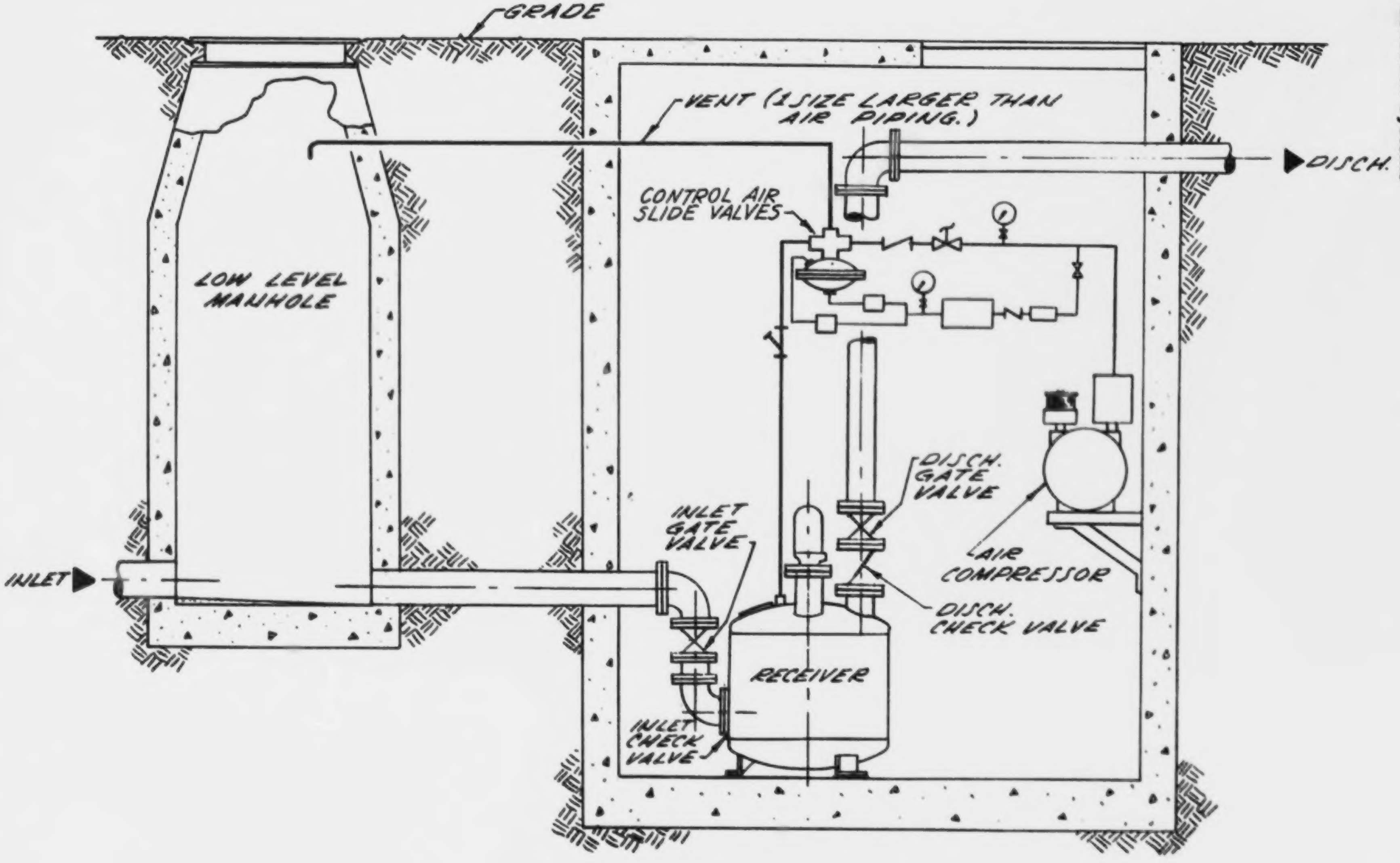

GRADE
VENT (1 SIZE LARGER THAN AIR PIPING.)
DISCH.
CONTROL AIR SLIDE VALVES
LOW LEVEL MANHOLE
DISCH. GATE VALVE
INLET GATE VALVE
AIR COMPRESSOR
INLET
DISCH. CHECK VALVE
RECEIVER
INLET CHECK VALVE

Fig. 8.9 Manhole wet well and pneumatic ejector dry well station
(Courtesy of James Equipment and Manufacturing Company)

8.13 Lift Station Requirements

The most desirable operation of a lift station would be the situation where all the flow and solids that discharge into the wet well from the gravity sewer are lifted to the higher elevation and continue to the wastewater treatment plant without delay. This would occur with the highest use of equipment and energy efficiency possible. Also operational and maintenance problems would be minimized.

Some lift stations almost meet these ideal requirements, but there are many more that are unable to meet these requirements. Usually a lift station is designed to handle expected peak flows. Often this means that long detention or holding times occur in wet wells during low flow periods. Provisions for wet well aeration during low flow periods could help keep the detained wastewater fresh. Do not introduce excessive air into wet wells of pumping stations with long force mains with numerous high points. Released air can accumulate in the high points in a force main and cause an air bubble to form, which reduces the effective diameter of the pipe. This will result in higher pumping costs and reduced pipe flow capacity. In addition, accumulated air in the force main can contribute to a phenomenon known as "water hammer" in which extremely high pressure shock waves travel up and down the force main. Water hammer can cause broken force mains or piping within the pump station. Trapped air in the force main is usually associated with check valve "slamming" which frequently produces a force strong enough to damage check valves and piping in the station, thus causing a failure flooding. Air release valves are normally installed at high points in the force main to automatically blow off accumulated air (Figures 8.10 and 8.11).

ECONOMIC
FACTORS

The most critical component of a lift station is the pumping unit; but pipes, valves, controls and power supply also are essential. All of these items must be "go" or the lift station will fail.

1. *FLOW*

Most pump capacities are rated in GPM (gallons per minute). The design engineer must carefully estimate flows under operating conditions to select the proper pump or pumps for the lift station. Important operating conditions include:

Flow, Q_1 = Average daily dry weather flow,

Flow, Q_2 = Seasonal dry weather flow,
(to handle industrial flows that produce high flows for 1 to 3 month periods such as canneries), and

Flow, Q_3 = Peak wet weather flow
(based upon a one-in-ten-year occurrence or some other severe storm frequency that produces conditions where inflow/infiltration may enter the collection system, especially important in combined wastewater and storm water collection systems).

Under certain circumstances, Q_2 and Q_3 may range from 1.5 to 10.0 times or more above Q_1. These high flows present greater problems in smaller lift stations than in the larger stations with multiple pumping units. All but the smallest lift stations should have sufficient pump capacity to handle peak flows. During usual or average flow conditions, the pumps that handle peak flows can serve as backup units during periods when the other pumps are shut down for maintenance and repairs.

2. *HEAD*

The term *HEAD* refers to pressure head (pounds per square inch or psi) or elevation head (feet). Head is a verticial distance and is measured as the difference in elevation between two points. Head may be expressed in feet or psi.[3] Important head terms that should be known when pumps are selected include *SUCTION HEAD, DISCHARGE HEAD, TOTAL STATIC HEAD*, and *TOTAL DYNAMIC HEAD*.

Suction heads may be positive or negative (suction lift), depending on whether the water level in the wet well is above (positive) or below (negative) the center line of the pump impeller. Discharge heads are measured on the discharge side of a pump from the center line of the pump to an elevation on the discharge side. Static heads are shown on Figure 8.12 and dynamic heads on Figure 8.13. Static heads are measured when the pump is not operating and are the differences in elevation (in feet) between the surface of the water on the suction side of the pump and the surface of the water on the discharge side of the pump. Dynamic heads are measured when the pump is operating and depend on the velocity of water in the pump suction and discharge pipes.

---

[3] *A column of water 2.31 feet high creates a pressure of 1 pound per square inch (psi) at the bottom of the column. Therefore*
1 psi = 2.31 ft
and 1 ft = 0.433 psi.

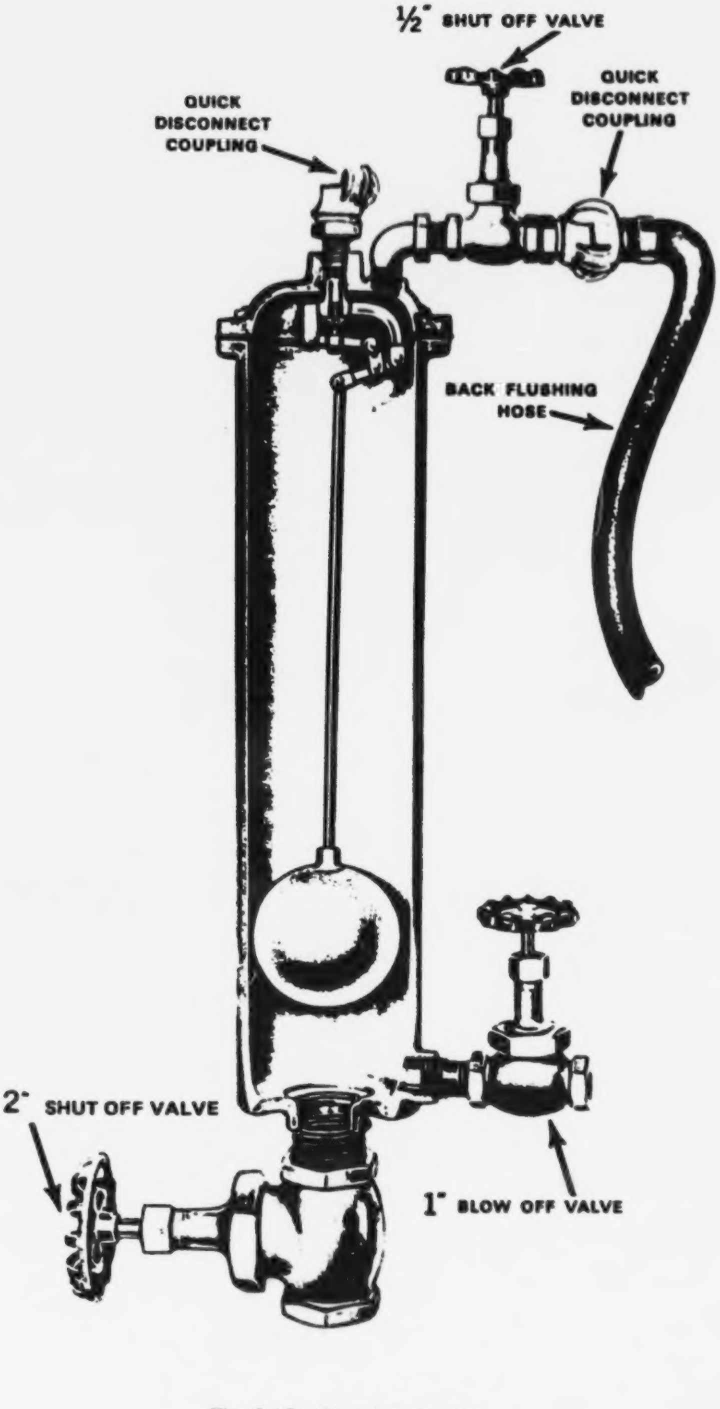
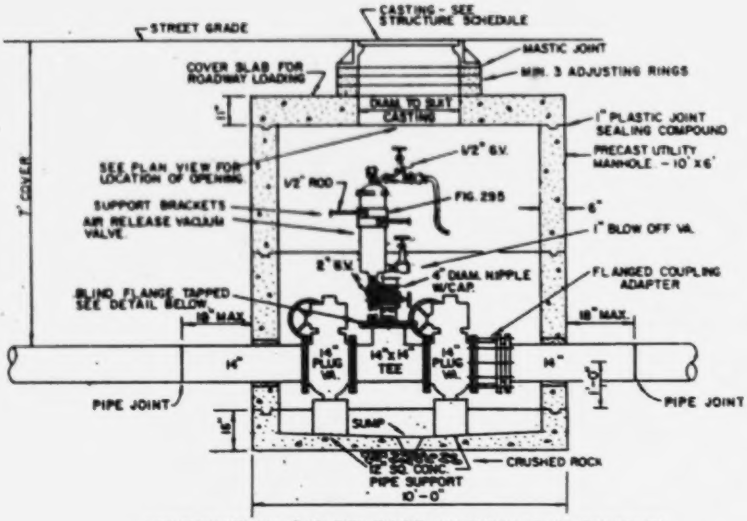
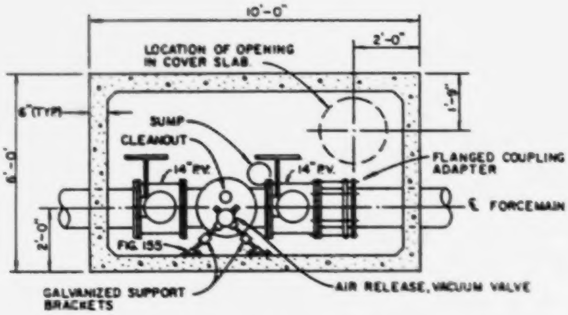

½" SHUT OFF VALVE
QUICK DISCONNECT COUPLING
QUICK DISCONNECT COUPLING
BACK FLUSHING HOSE
2" SHUT OFF VALVE
1" BLOW OFF VALVE

Fig. 8.10 Air release valve
(Permission of APCO)


STREET GRADE
CASTING - SEE STRUCTURE SCHEDULE
MASTIC JOINT
MIN. 3 ADJUSTING RINGS
COVER SLAB FOR ROADWAY LOADING
11"
DIAM. TO SUIT CASTING
1" PLASTIC JOINT SEALING COMPOUND
PRECAST UTILITY MANHOLE - 10' X 6'
1/2" G.V.
SEE PLAN VIEW FOR LOCATION OF OPENING
1/2" ROD
7' COVER
FIG. 295
SUPPORT BRACKETS
6"
AIR RELEASE VACUUM VALVE
1" BLOW OFF VA.
2" G.V.
4" DIAM. NIPPLE W/CAP.
FLANGED COUPLING ADAPTER
BLIND FLANGE TAPPED SEE DETAIL BELOW
18" MAX.
18" MAX.
14"
14" PLUG VA.
14"x14" TEE
14" PLUG VA.
14"
1'-0"
PIPE JOINT
PIPE JOINT
16"
SUMP
12" SQ. CONC. PIPE SUPPORT
CRUSHED ROCK
10'-0"

COMBINATION AIR RELEASE, VACUUM & CLEANOUT
MANHOLE TYPE S-6
NO SCALE


10'-0"
2'-0"
LOCATION OF OPENING IN COVER SLAB
1'-9"
6" (TYP)
SUMP
CLEANOUT
6'-0"
14" P.V.
14" P.V.
FLANGED COUPLING ADAPTER
℄ FORCEMAIN
2'-0"
FIG. 155
GALVANIZED SUPPORT BRACKETS
AIR RELEASE, VACUUM VALVE

PLAN VIEW MANHOLE TYPE S-6
NO SCALE

Fig. 8.11 Installation of air release valve in a force main

NOTE: This figure illustrates a pump with a suction *LIFT*. Pumps should have a suction *HEAD* which means the wet well water level should be higher than the pump impeller. This pump will have difficulty starting unless it is a self-priming pump because the water level in the wet well is below the pump. Also, if air gets into the suction line, the only way it can get out is through the pump.

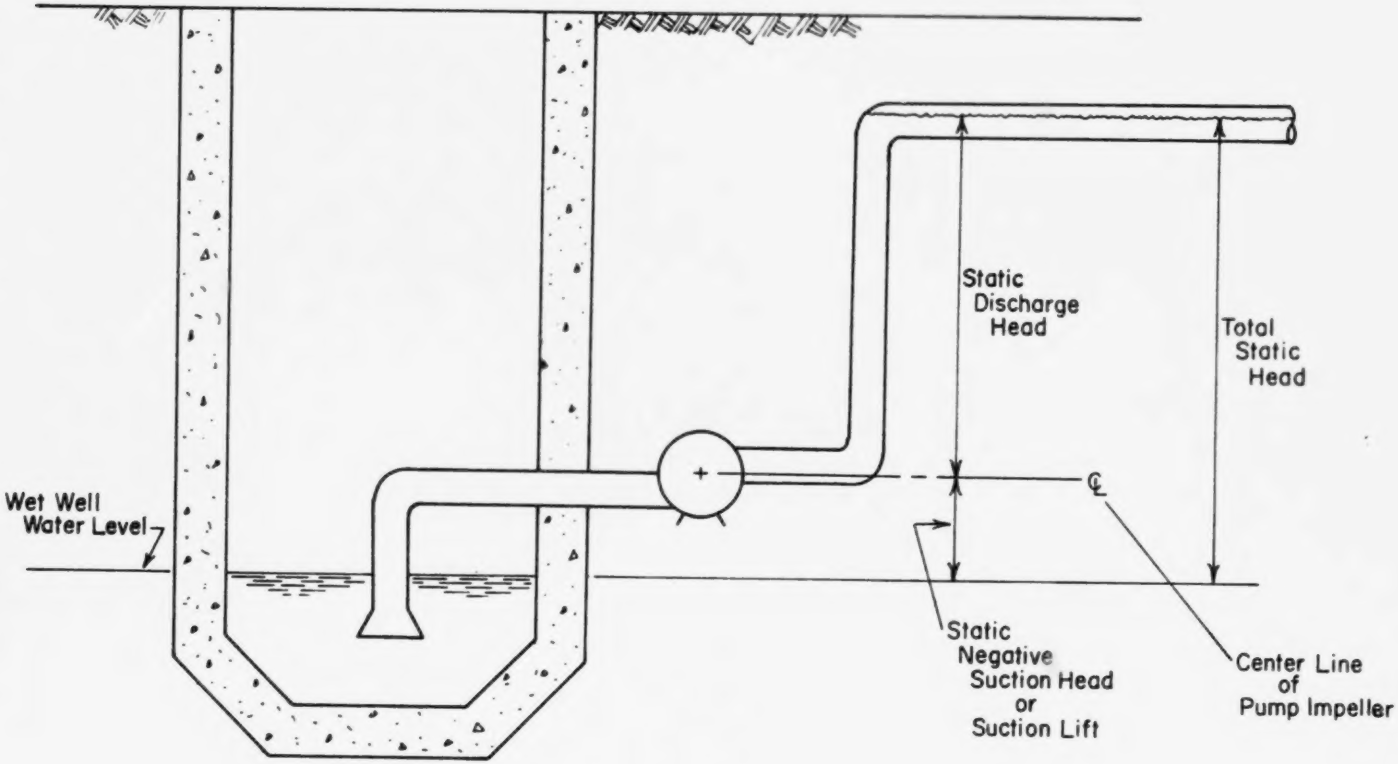
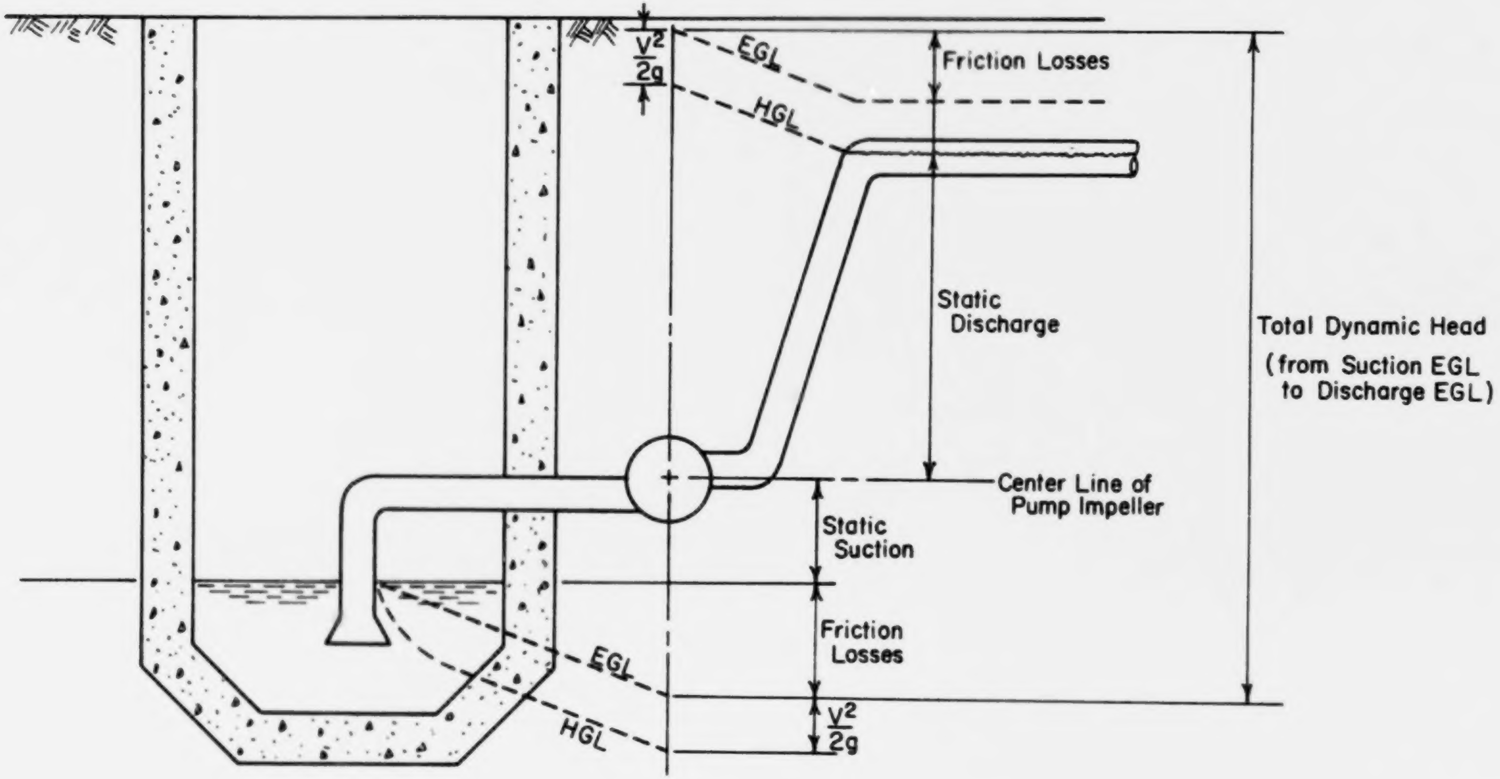

Static Discharge Head
Total Static Head
℄
Wet Well Water Level
Static Negative Suction Head or Suction Lift
Center Line of Pump Impeller

Fig. 8.12 Static heads (pump is not operating)

NOTE: This figure illustrates a pump with a suction *LIFT*. Pumps should have a suction *HEAD* which means the wet well water level should be higher than the pump impeller. This pump will have difficulty starting unless it is a self-priming pump because the water level in the wet well is below the pump. Also, if air gets into the suction line, the only way it can get out is through the pump.


$\frac{V^2}{2g}$
EGL
HGL
Friction Losses
Static Discharge
Total Dynamic Head (from Suction EGL to Discharge EGL)
Center Line of Pump Impeller
Static Suction
Friction Losses
EGL
HGL
$\frac{V^2}{2g}$

EGL- Energy Grade Line

HGL- Hydraulic Grade Line

$\frac{V^2}{2g}$ - Velocity Head

Fig. 8.13 Dynamic heads (pump is operating)

Dynamic heads are greater than static heads because they include the static heads plus the friction losses in the suction and discharge pipes. The energy required to start a pump is greater than the total dynamic head (TDH) during normal operating conditions because additional energy is required to start the motor and the pump and to start the water flowing through the pipes, the check valves, and the pump.

Friction losses result from pipe friction and the friction losses due to the water flowing through pipe fittings such as valves, reducers and elbows. The greater the velocity of flow in pipes, the greater the friction losses. Suction pipes are often larger in diameter than discharge pipes to reduce friction losses in the suction pipe and thus also to reduce *CAVITATION*[4] problems. However, cavitation problems are more likely to be caused by excessive tip speed of the impeller, air leaks on the suction side of the pump, and restrictions in the suction line. Friction losses may be calculated from tables in pump and pipe handbooks by knowing the flow (in GPM) and the diameter, type, and length of pipe and also the size and type of valves and fittings. See Appendix A.88, Friction or Energy Losses, in Volume I.

Design engineers try to minimize friction losses by careful layout of pipes, selection of pipe size (diameter) and length, and the number of valves and fittings. Consideration must be given to friction losses at expected flows and suction conditions when determining desired pump characteristics and selecting a pump. If the lift station piping and pumps are not properly designed, problems can develop from vibrations, cavitation, and insufficient pumping capacity, thus requiring excessive maintenance.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 89.

8.1F What is the most desirable operational situation for a wet well?

8.1G What is the difference between static and dynamic head?

8.1H Friction losses are caused by what factors in a lift station?

END OF LESSON 1 OF 5
ON
LIFT STATIONS

DISCUSSION AND REVIEW QUESTIONS

Chapter 8. LIFT STATIONS

(Lesson 1 of 5 Lessons)

At the end of each lesson in this chapter you will find some discussion and review questions that you should answer before continuing. The purpose of these questions is to indicate to you how well you understand the material in the lesson. Write the answers to these questions in your notebook before continuing.

1. What is the purpose of a lift station?
2. Where are lift stations located?
3. Describe the ideal result of operating a lift station.
4. Why does a pump require more energy (draw more power) to start than it does during normal operating conditions?

---

[4] *Cavitation (CAV-i-TAY-shun). The formation and collapse of a gas pocket or bubble on the blade of an impeller. The collapse of this gas pocket or bubble drives water into the impeller with a terrific force that can cause pitting on the impeller surface.*

CHAPTER 8. LIFT STATIONS

(Lesson 2 of 5 Lessons)

8.2 COMPONENTS OF A LIFT STATION

8.21 Wet Wells

The wet well size and shape and the equipment located in it must be carefully designed in order to allow proper operation of the pumping equipment and to allow the operator to maintain the wet well area.

8.210 Wet Well Dimensions

The wet well size affects many operating conditions of the lift station; however, many of these are fixed at the time of design which limits the improvements an operator can make if problems develop or exist.

The length, width and usable depth will affect the cycle (on-off) time of the pumps since the wet well acts as a storage basin. If the capacity of the wet well is too small, excessive starting and stopping of the pump motors will occur which will ultimately result in a premature failure of the motor winding insulation.

Cycle times should be calculated for minimum, maximum, and peak flow periods. The ability of a motor to withstand frequent starting is generally limited by the motor size and, in the larger horsepowers, may be limited to as few as five starts per hour (see Chapter 9, Section 9.2, AC Induction Motor Maintenance).

If, however, the wet well is too large, solids will tend to accumulate on the bottom since the wet well will be acting as a settling tank, similar to what occurs in a treatment plant sedimentation tank or clarifier. If solids accumulate in the tank they could partially or totally obstruct the pump suction pipes and, over a period of time, microorganisms decomposing the organic material will generate hydrogen sulfide (toxic) and methane (explosive) gas.

Therefore, the design engineer may have to compromise between motor cycle time, minimum and maximum flows, and the detention time period. This may require annual, semi-annual, or even more frequent removal of the solids from the wet well using a vacuum-type cleaning machine.

Another method of cleaning the wet well is the use of high pressure water from the hydraulic cleaning (jet) machine. **WARNING:** As the solids are disturbed they may release hydrogen sulfide and methane gas. Also, the introduction of large quantities of solids in a short period of time into the pump suction could cause pumps to become partially or fully plugged and actually damage the pumps.

8.211 Flow Distribution

Flow distribution from the influent pipe in the wet well can create operating problems if the wastewater flow discharges directly opposite one or more of the pump suction pipes. Normally, this flow is aerated so that it contains large amounts of air. As the entrained air rises to the surface, it can accumulate in the suction pipe causing the pump to become air-bound. Then, when the pump is turned on, it will not pump the wastewater. Entrained air frequently contributes to pump cavitation which can rapidly destroy the impeller or wear rings and other pump components in the liquid end of the pump. This situation is usually caused by improper design and the operator has limited options available for correction; however, construction of a baffle to divert the flow may be effective.

8.212 Operating Levels

The operating levels in a lift station are determined by the high and low water levels in the wet well. The high water level is usually limited to the invert of the incoming gravity pipe, since it is not desirable to allow "backup" into the incoming gravity pipe. The lowest water level is usually defined by the center line of the pump impeller. When using pumps that are not self-priming, the wet well water level should not be drawn down below the center line of the pump impeller.

Too small a distance between the gravity pipe invert and the center line of the pump contributes to the short cycling of the pump motors. Automatic Lead/Lag alternation of the pumps, which selects a different pump each time a complete pump-on/pump-off cycle is completed, is an effective way to minimize short cycling.

The minimum required wet well level (submergence), in some cases, may be higher than the center line of the pump impeller depending on the suction line size and pump capacity. Even though the minimum water level is above the center line of the impeller, a condition called "vortexing" may occur. This happens when the water is being drawn into the pump so rapidly that a vortex or whirlpool forms on the surface of the water. This turbulence draws excessive amounts of air into the pump suction along with the wastewater. Although the vortex is usually visible to the naked eye and can be observed while the pump is pumping, it can be difficult to detect. The only solution is to raise the minimum operating level for the pumps; however, this will then affect the number of times per hour that the pump motors start. Submergence is illustrated in Figure 8.14 and examples of how to calculate submergence are provided.

Aeration systems in the wet well are sometimes necessary to reduce odors in the wet well if detention times are

SUBMERGENCE DESCRIPTION:

Air may be entrained in the pumped liquid if the pump suction is located too close to the water surface in the suction source. Pumping wastewater with entrained air can cause a reduction of capacity, rough and noisy operation, vibration, loss of efficiency and wasted power. Excessive wear of close-running parts, bearing stresses and shaft damage are also subsequent effects.

EXAMPLES (see drawing below):

1. When the pipe size is known, the minimum submergence required for 2000 GPM through an 8-inch diameter pipe is 9.6 feet.
2. When the inlet area is known, the minimum submergence required for 2000 GPM, 8-inch pipe through a 50 square inch outlet is 9.6 feet. Minimum submergence requirements may exceed the available space requirements. When this occurs a larger pipe size or inlet will reduce the required submergence.
3. The minimum submergence required for 2000 GPM through a 10-inch pipe is 4.6 feet (5.0 feet less than required for an 8-inch pipe).

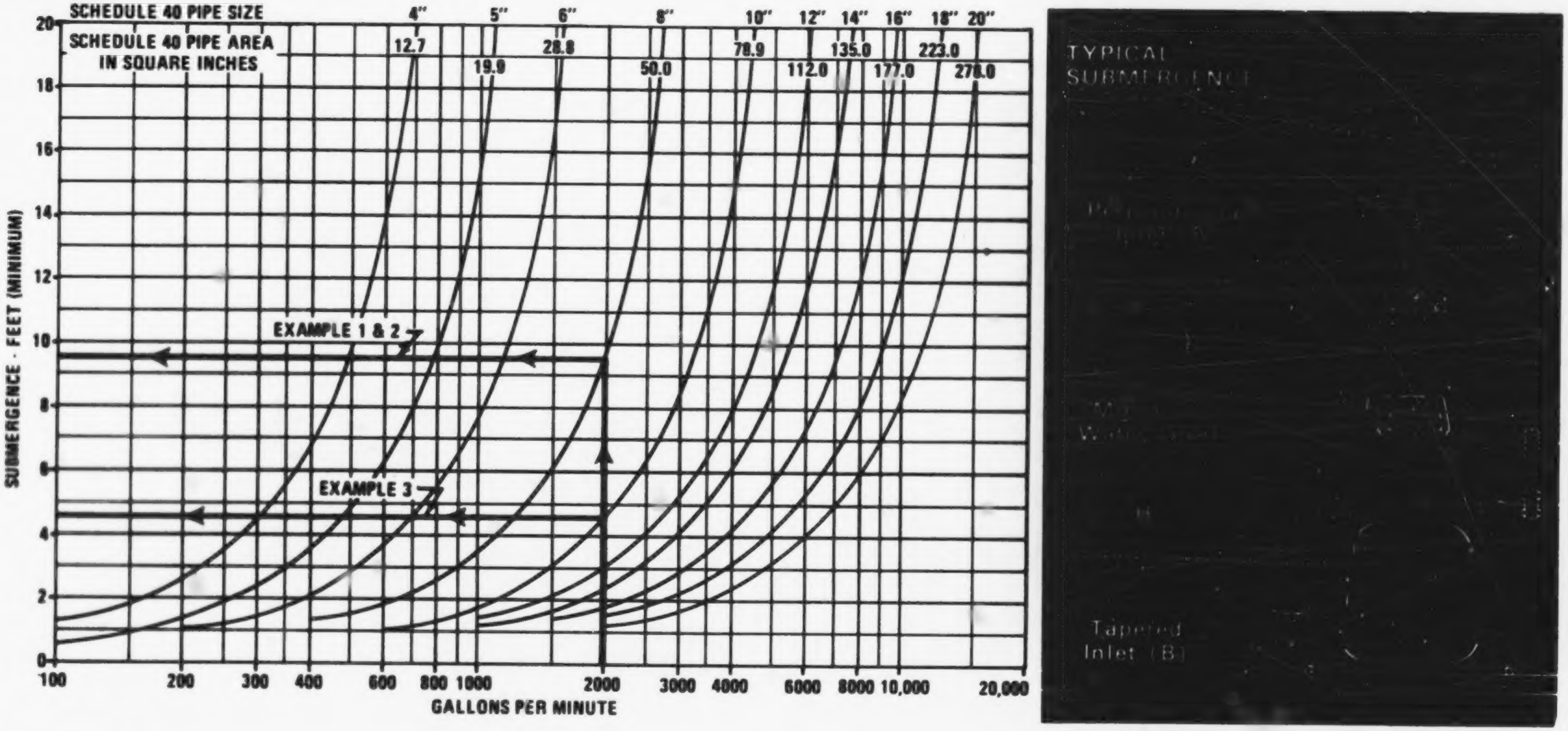


Fig. 8.14 Determination of minimum submergence depth

excessive or if the wastewater reaching the wet well is septic due to warm temperatures and long travel times in the sewers. These systems may be another source of entrained air creating pump operating problems and/or air accumulation in the force main.

Many lift stations built since the 1960's have variable-speed pumps that adjust pump speed and pump capacity in an attempt to match the pumping rate with the flow rate into the wet well. In many cases, however, the wet well in these types of installations may not be of adequate size, since there are a number of factors in the pumping system that determine whether or not the pump's speed will actually be able to match the incoming flow. If the variable-speed pumping system works as intended, it does provide an almost constant flow to the treatment plant which results in an easier operation of the plant. On the other hand, if pumps located near a treatment plant come on and off according to levels in a wet well, the treatment plant receives surges of wastewater that are difficult to handle.

8.213 Wet Well Access

Larger lift stations which require frequent access by the operator to perform routine maintenance should have stairs constructed in them. Stairs should be built of a corrosion-resistant material such as fiberglass or aluminum, since steel will deteriorate in the corrosive atmosphere of the wet well. Similarly, doors or access hatches should be made of a noncorrosive material.

Environmental conditions can also create problems for wet well access, particularly below-freezing weather in the northern climates. Frost and ice buildup tend to accelerate rusting of metal doors. Ice buildup may actually freeze the door shut.

If the wet well contains a bar screen, a method of material handling must be provided so that screenings can be removed from the wet well. Floats, bubblers, fixtures, metering flumes or other equipment which require maintenance in the wet well should be easily accessible.

8.214 Wet Well Inlet Channel

The inlet channel of larger stations must be designed to allow proper flow distribution throughout the wet well and to minimize problems of solids settling and submergence described in previous sections.

A split wet well which allows isolation of one half of the wet well and pump sections is a desirable feature, particularly in larger stations. Frequently, a flume-type flow metering device is also located in the inlet channel to measure the flows being pumped.

8.215 Wet Well Safety

Wet wells are defined by most agencies as confined spaces. All the safety procedures and equipment recommended in Chapters 4 and 11 should be reviewed carefully and implemented when working in the wet well area.

Hydrogen sulfide and other toxic gases, oxygen deficiency, and explosive atmospheres are all conditions which can exist in the wet well. In addition, slippery ladders or stairs caused by the buildup of slime and the continual presence of moisture can create slipping and falling hazards.

If the wet well has standard manhole steps for access, they should not be depended on to be structurally sound. After a period of time, corrosion will cause the steps to fail and this could be fatal to the operator.

8.216 Wet Well Hardware

All hardware in the wet well used for fastening piping, platforms, or stairs should use stainless steel anchor bolts or other non-corroding material. Aluminum ladders and platforms are popular because of their corrosion resistance features. However, aluminum must not come in direct physical contact with concrete since this will result in corrosion of the aluminum. Handrail supports, for example, set into concrete without any protective coating will eventually corrode at the interface where the aluminum enters the concrete, resulting in a failure of the handrail when an operator or a visitor leans against it.

8.217 Wet Well Electrical Systems

The wet well atmosphere can contain explosive or flammable gases and is classified as a Class 1, Division 1 area (National Electrical Code). Any electrical systems must either be explosion-proof or be rated as intrinsically (by its very nature) safe. Equipment installed in the wet well should be kept to a minumum since maintenance can be very difficult. Changing a light bulb in an explosion-proof fixture may be impossible, for example, because of corrosion of the machined surfaces and threads in the fixture. Replacement of the entire fixture would then be necessary.

Standard galvanized conduit and fittings will corrode rapidly in the wet well atmosphere, and therefore, aluminum conduit and fittings or PVC-coated conduit should be used. Fixtures and alarm floats should be easily accessible and not require the operator to increase the possibility of slipping of falling. If possible, do not install fans, blowers, or motors in the wet well because of the corrosive conditions.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 89.

8.2A Why should the pumps in a lift station not start and stop frequently?

8.2B What problems develop in a wet well that is too large?

8.2C What is the main advantage of variable-speed pumping equipment?

8.22 Bar Racks

Installation of bar racks or screening devices in the wet well used to be a common practice, especially on the older combined wastewater and storm water collection systems due to the debris entering the system from the surface runoff drains containing leaves, sticks, cans, and trash. In collection systems for only domestic and industrial wastewaters, bar racks or screens have been eliminated by some agencies at the lift station because most pumping units are equipped with open *IMPELLERS*[5] or closed two-port impellers sized to pass solids up to the size of a 2.5-inch diameter sphere. This is the largest size sphere which may pass through most home lavatory and disposal systems.

Bar racks are installed to prevent any large debris from entering and plugging or damaging a pump. In areas where vandals remove manhole covers and throw junk into sewers, bar racks may be helpful. When bar racks are used, they should be cleaned frequently so there is no substantial restriction of wastewater flow to the pumps. The cleaning of bar racks is accomplished with forks, screen baskets, or any type of tool capable of picking up the debris and removing it from the bar racks. A limitation of bar racks is the fact that screenings cause odors and attract flies.

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[5] *Impeller. A rotating set of vanes in a pump designed to pump or lift water.*

Screenings are usually removed from the station in buckets and transported to a disposal site. Agencies that have removed bar screens from lift stations which pump sanitary wastewater have found the pump impellers occasionally become plugged with rags (two to three times a year). However, this problem is preferred to the necessity of visiting a station one or two times a day to clean a screen and struggle with hauling the screenings to a disposal site. Many pumps are designed to "chew" the rags into a size small enough to be pumped.

In larger lift stations, some agencies are installing *COMMINUTORS*[6] and barminuters to shred rags and debris ahead of wet wells and pumps. A by-pass channel with a rack is needed for use when the comminutor is being repaired.

8.23 Dry Wells

A dry well is that portion of the lift station which is isolated from the wastewater and used to house the necessary equipment for the lift station to function. The structure commonly has two or more floor levels. The lower floor usually contains the pumping units, isolation valves, discharge manifold (pipes), and a sump pump to remove excess water such as seal water leakage and clean up water.

Electrical control boards, motors, ventilation equipment, necessary station controllers and auxiliary equipment are housed on the upper floor. This provides protection to station equipment in case of a broken valve or fitting or a leak that would permit wastewater to flow from the wet well or force main into the dry well side of the station. Flooding of the lower level could occur, but the electrical systems, motors and expensive control equipment would be protected from water damage and would allow the station to be put back into service very quickly.

8.24 Electrical System

8.240 Typical Systems

With the exception of very small lift stations such as grinder pump stations that serve one or two residential services, electrical power is three-phase utility power. Single-phase systems are limited to about five horsepower since beyond that, wire, controller equipment and other components increase dramatically in size to carry the amount of current required for a single-phase system. Three-phase electrical systems are able to operate higher horsepower loads because the current is distributed over the three phases and three individual sets of conductors.

Figure 8.15 illustrates a block diagram of a typical lift station electrical system. Figure 8.16 is a one line riser diagram of a power and control center for a lift station which contains four pumps, alarm system, and a standby emergency generator.

8.241 Power Transformers

Power is supplied by the utility company through one or more pole-mounted transformers or a pad-mounted transformer. The power company usually supplies a high voltage; for example, 13,800 volts (13.8 KV). The transformer(s) steps this voltage down to 3-phase 208, 220, 240, 440, 460, or 480 volt systems at a frequency of 60 cycles per second (60 Hz). In larger pump stations the operating voltage for the motors may be higher than 480 volts; however, this is not common except in extremely large pump stations. For purposes of discussion, let us assume that in this particular pump station the utility company transformer steps the voltage down to 480 volts, 3-phase.

8.242 Metering

Power is fed into the power company metering which is usually a watt/hour meter. A demand meter which measures the peak electrical demand required by the pump station, usually on a monthly basis, may also be installed. Peak demand in a multiple-pump station usually occurs when all pumps are operating at peak flow conditions. In some cases, the power company may impose a penalty on the user for high demand conditions. Coordinating pump operation to reduce maximum electrical demand is one area an agency should examine to reduce station electrical operating costs.

8.243 Main Disconnect

The main disconnect switch may be fused, a circuit breaker, or simply a disconnect switch to allow isolation of the entire electrical system within the pump station. In newer stations, this section also may contain a Ground Fault Interrupter (GFI) circuit.

8.244 Transfer Switch

If the pump station is supplied with either a permanently installed emergency generator or provisions for a portable unit, a transfer switch is used which may either be manually operated or automatically operated when the utility power source is lost. Pump stations with an automatic transfer switch will also have an automatic control system to start up and operate the emergency engine-generator set.

Pump stations may also have provisions for connecting a portable standby power system which, again, is an engine-driven generator that can be towed to the site and plugged in.

8.245 Motor Control Center (MCC)

The motor control center, or main panel as it is sometimes called, houses the controls for all motors and electrical

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[6] *Comminutor (com-mih-NEW-ter). A device used to reduce the size of the solid chunks in wastewater by shredding (comminuting). The shredding action can be visualized if you imagine many scissors cutting to shreds all of the large solids in the wastewater. Barminuter (bar-mih-NEW-ter). A device similar to a comminutor.*

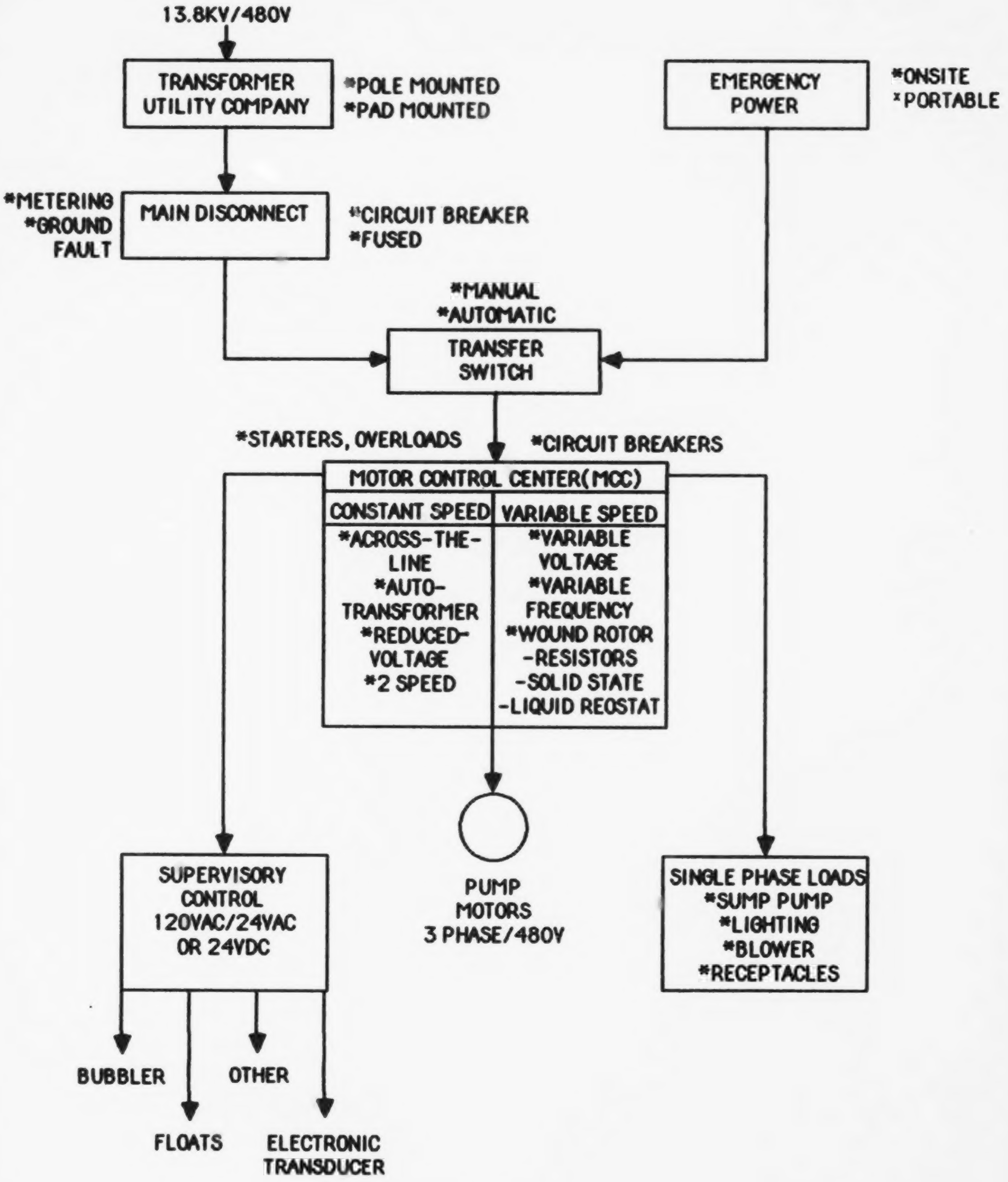

13.8KV/480V
TRANSFORMER UTILITY COMPANY
*POLE MOUNTED
*PAD MOUNTED
EMERGENCY POWER
*ONSITE
*PORTABLE
*METERING
*GROUND FAULT
MAIN DISCONNECT
*CIRCUIT BREAKER
*FUSED
*MANUAL
*AUTOMATIC
TRANSFER SWITCH
*STARTERS, OVERLOADS
*CIRCUIT BREAKERS
MOTOR CONTROL CENTER(MCC)
CONSTANT SPEED
*ACROSS-THE-LINE
*AUTO-TRANSFORMER
*REDUCED-VOLTAGE
*2 SPEED
VARIABLE SPEED
*VARIABLE VOLTAGE
*VARIABLE FREQUENCY
*WOUND ROTOR
-RESISTORS
-SOLID STATE
-LIQUID REOSTAT
SUPERVISORY CONTROL 120VAC/24VAC OR 24VDC
PUMP MOTORS 3 PHASE/480V
SINGLE PHASE LOADS
*SUMP PUMP
*LIGHTING
*BLOWER
*RECEPTACLES
BUBBLER
OTHER
FLOATS
ELECTRONIC TRANSDUCER

Fig. 8.15 Block diagram, typical pump station electrical system

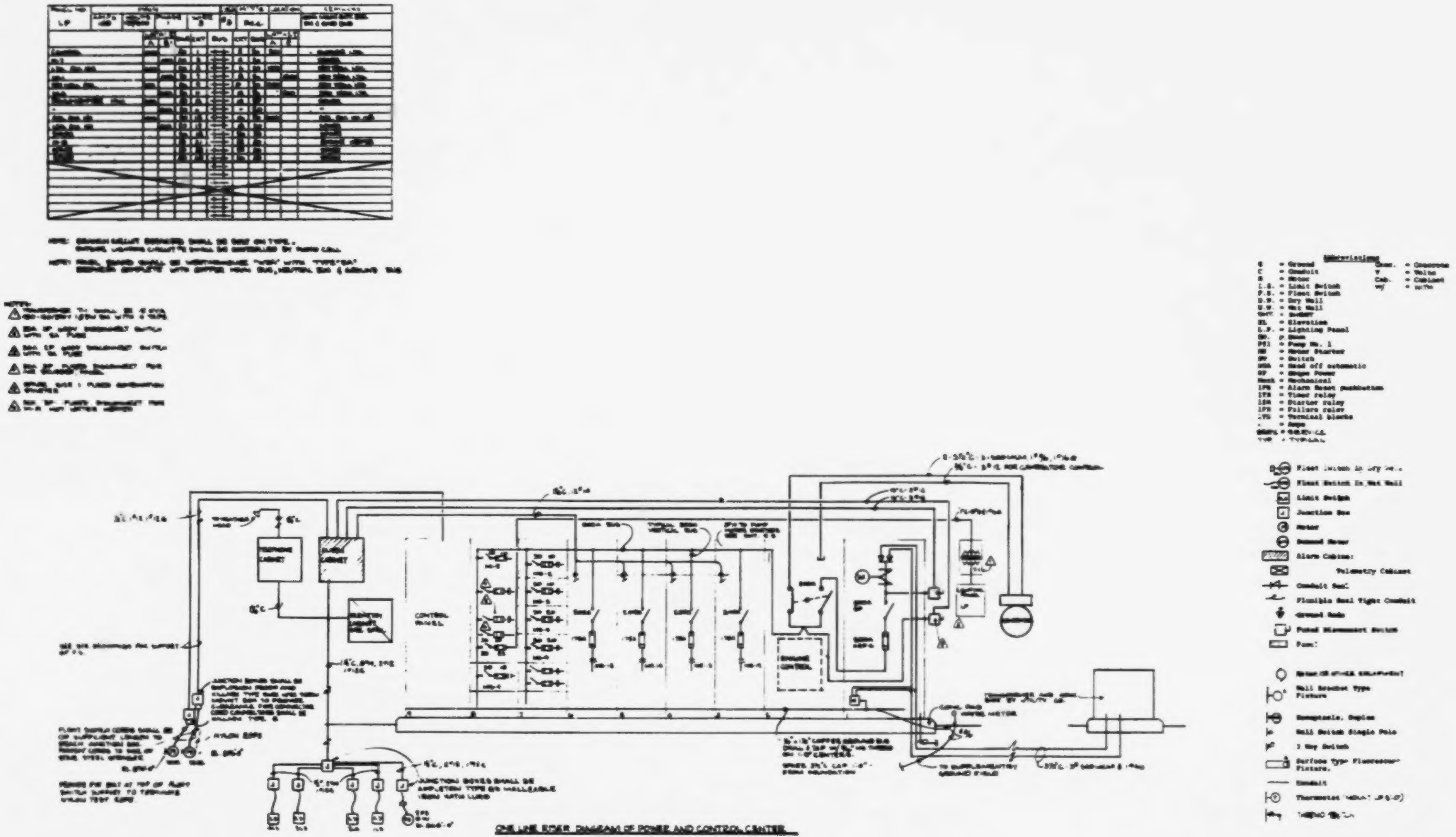

Abbreviations
G = Ground
C = Conduit
M = Motor
L.S. = Limit Switch
F.S. = Float Switch
D.W. = Dry Well
W.W. = Wet Well
EL = Elevation
L.P. = Lighting Panel
P#1 = Pump No. 1
= Motor Starter
= Switch
= Hand off automatic
= Mechanical
= Alarm Reset pushbutton
= Timer relay
= Starter relay
= Failure relay
= Terminal blocks
= Amps
Conc. = Concrete
V = Volts
Cab. = Cabinet
w/ = with
Float Switch in Wet Well
Limit Switch
Junction Box
Motor
Alarm Cabinet
Telemetry Cabinet
Conduit Seal
Flexible Seal Tight Conduit
Ground Rods
Fused Disconnect Switch
Wall Bracket Type Fixture
Receptacle, Duplex
Wall Switch Single Pole
3 Way Switch
Surface Type Fluorescent Fixture
Conduit
CONTROL PANEL
ONE LINE RISER DIAGRAM OF POWER AND CONTROL CENTER
NO SCALE
SERVICE VOLTAGE 277/480 3Ø 4W

Fig. 8.16 One line riser diagram of a power and control center

equipment operated within the station. These controls include a starter, fuses, heater strips and all the coils and relays necessary for any particular pump or motor to operate.

The motor control center is fed 480V, three-phase power and contains branch circuit breakers, starter devices, three-phase overload relays, and a low voltage control circuit for starter coil operation and indicating lights. Each three-phase motor will have these control components in the circuit. (See Chapter 9 for component details.)

For small, constant-speed pump motors, power is supplied to the motor via the starter contacts. This is referred to as across-the-line starting (ACL). In larger motors it is common practice to use an additional control section to reduce starting currents, since across-the-line starting will require motor starting currents of six to eight times the normal running currents. Frequent starts for a motor are not good because high starting currents generate heat in the windings which cannot be dissipated. If the winding temperature is exceeded, the insulation will break down and cause a short within the motor windings.

Other types of starting methods are also used. In some motors, different sets of built-in windings are connected during the start phase and the run phase; this is known as reduced voltage starting. In the auto-transformer starting system, different values of transformer-type windings are switched to limit the amount of current during the start phase. Another altnerative is to use two-speed motors. These may be used if the speed is selected to correspond to the incoming flow of the wet well. All of these methods require some sort of additional starter contacts and control arrangements for each motor utilizing them.

Variable-speed motors are often used in an attempt to match the pumping rate to the incoming wet well flow. Types of variable-speed systems typically used are:

1. Variable voltage,
2. Variable frequency (VFDs), and
3. Wound-rotor motor using variable resistances in the secondary winding of the motor to change the operating speed of the motor. This is accomplished by:
    a. Metal resistors where different values of metal resistors are switched by a controller,
    b. Liquid rheostat which varies the resistance in the secondary by varying the level of a conducting liquid on electrodes, and
    c. Solid state devices which vary the resistance in the secondary using silicon-controlled rectifiers (SCRs).

8.246 110-Volt/220-Volt Loads

In addition to the power levels discussed in Section 8.241, there are also single-phase, 110-volt/220-volt loads in most stations. An additional transformer is required to convert the 480 volt, 3-phase to 110/220 volt, 1-phase. Typically, 120-volt loads would be used for lighting systems, sump pumps, ventilation blowers, and convenience receptacles.

8.247 Supervisory Controls

The supervisory control panel, which controls the operation of the pump motors, is usually powered with single-phase, 120-volt current. An additional step-down transformer may be used to reduce control voltage to 24-volt AC or 24-volt DC (24 VAC, 24 VDC). There are several different methods of measuring the liquid level in the wet well. The supervisory control system uses this signal to turn the pump motors on and off. The two most popular methods are the air-operated bubbler system and the electrically operated float system. Recently, electronic transducers have also been developed which convert wet well level into an electrical signal.

8.25 Motors (See Chapter 9, Section 9.2, Electrical Equipment Maintenance)

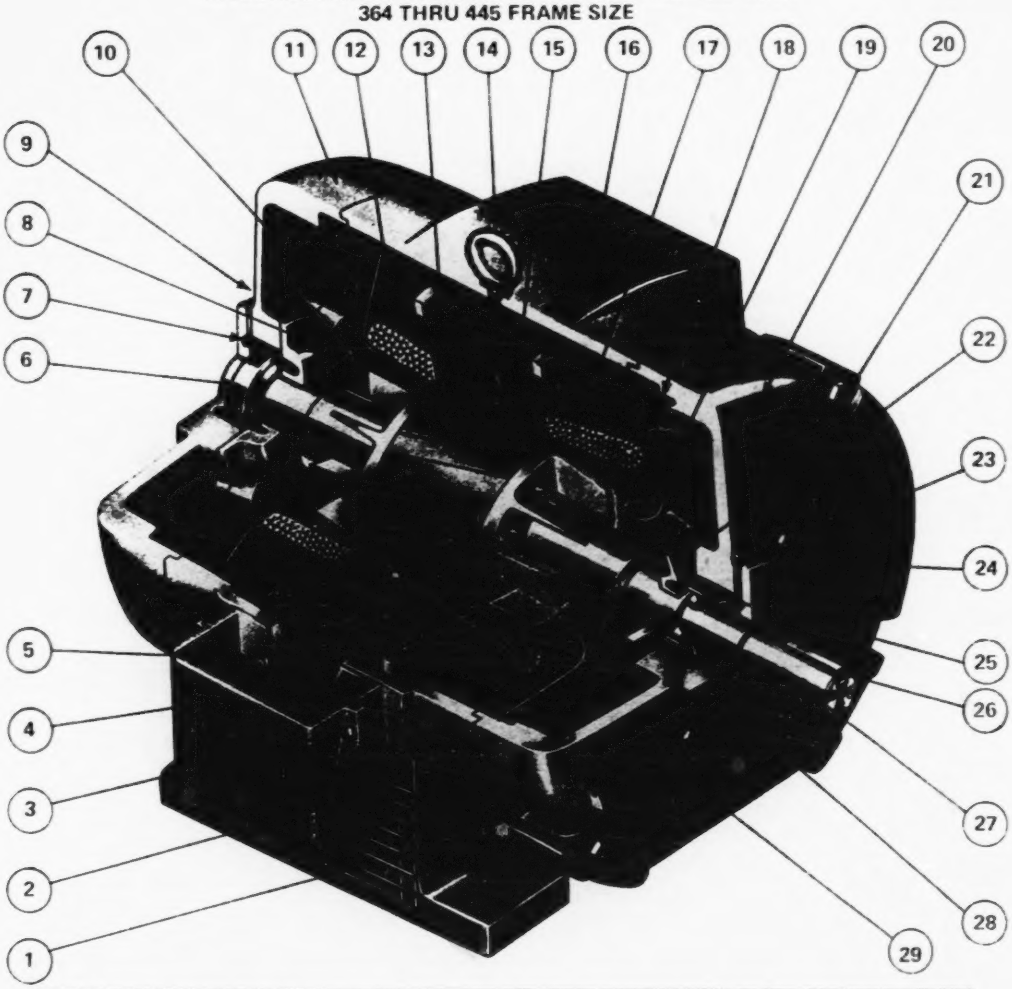
Motors can have different voltages, horsepowers and ampere readings. Also, they will be rated at 60 cycles and single-phase or three-phase. Voltage ratings depend on the local power source and may be 208, 220, 440, 460, 480 volts or higher for very large stations, 60 cycles, and three-phase. Occasionally in a very small lift station a single-phase motor is used.

Submersible pump motors are an integral part of the pump and are encased in the pumping unit. When a seal fails on a submersible pump, the wastewater penetrates the motor compartment and burns or shorts out the motor. If a maintenance operator resets the unit and it operates properly for a short period of time with no overload, the operator can assume that a seal failure was not the reason for the shutoff, but that the pump had overloaded the motor. Determine the load on the motor and check for proper voltage. Also look for plugged lines and be sure wet well and pump are clear of rags, mud and debris that could cause a temporary overload.

By far the most common motor used in lift stations is the squirrel cage induction motor (SCIM). Figure 8.17 illustrates a typical horizontal squirrel cage induction motor and the various motor components. The term squirrel cage originated from earlier induction motors in which the rotor (rotating part) looked like a squirrel cage.

Three-phase power from the Motor Control Center (MCC) is applied to the stator winding (item 17 on Figure 8.17) which generates a rotating magnetic field. The rotor assembly (item 13), because of the way it is constructed, behaves like a transformer. Voltage is induced into the rotor which causes current flow and generates a second magnetic field in the rotor circuit. There are NO electrical connections between the stator windings and the rotor. It is the interaction of the two magnetic fields that causes the rotor to turn and to develop torque.

TYPICAL CUTAWAY VIEW
OF A MARATHON DESIGNED, DRIPPROOF, HORIZONTAL
INTEGRAL HORSEPOWER MOTOR & PARTS DESCRIPTION
364 THRU 445 FRAME SIZE



ITEM	DESCRIPTION	ITEM	DESCRIPTION	ITEM	DESCRIPTION
1.	**Frame Vent Screen	11.	Bracket O.P.E	21.	Bracket Holding Bolt
2.	Conduit Box Bottom	12.	Baffle Plate O.P.E.	22.	Inner Bearing Cap P.E.
3.	Conduit Box Top-Holding Screw	13.	Rotor Core	23.	Inner Bearing Cap Bolt
4.	Conduit Box Top	14.	Lifting Eye Bolt	24.	Grease Plug
5.	Conduit Box Bottom Holding Bolt	15.	Stator Core	25.	*Ball Bearing P.E.
6.	*Ball Bearing O.P.E.	16.	Frame	26.	Shaft Extention Key
7.	Pre-loading Spring	17.	Stator Winding	27.	Shaft
8.	Inner Bearing Cap O.P.E.	18.	Baffel Plate Holding Screw	28.	Drain Plug (grease)
9.	Grease Plug	19.	Baffle Plate P.E.	29.	** Bracket Screen
10.	Inner Bearing Cap Bolt	20.	Bracket P.E.		

P.E. = Pulley End
O.P.E. = Opposite Pulley End
* = Bearing Numbers are shown on motor nameplate when requesting information or parts always give complete motor description, model and serial numbers.
** = Bracket and frame screens are optional.

*** = Bearing Numbers are shown on motor nameplate. When requesting information on parts always give complete motor description, model and serial numbers.**
**** = Bracket and frame screens are optional.**

Fig. 8.17 Cutaway view of squirrel cage induction motor
(Courtesy of Marathon)

Some variable-speed systems in lift stations use a variation of the squirrel cage induction motor called the wound-rotor induction motor (WRIM). In this case, the rotor circuit is connected externally through the use of slip rings and brushes which allows the external connection of various values of resistance. This causes the rotor to change speed ranging from zero RPM when the rotor circuit is "open circuited" to full RPM when the rotor circuit is "short circuited."

Depending on space requirements in the station, motors and pumps may be mounted horizontally or vertically. The mounting configuration is unique for each design.

Motors are selected based on a number of factors as listed below:

- DESIGN - NEMA A, B, C, OR D
- HORSEPOWER
- SYNCHRONOUS SPEED-3600, 1800, 1200, RPM
- FRAME SIZE
- VOLTAGE
- FREQUENCY
- PHASES
- ENCLOSURE
- SERVICE FACTOR
- AMBIENT TEMPERATURE
- ENVIRONMENTAL CONDITIONS
- SPECIAL ELECTRICAL FEATURES
- SPECIAL MECHANICAL FEATURES
- MOUNTING
- TYPE BEARINGS REQUIRED
- DUTY-CONTINUOUS, 1 HOUR, ETC.

These features are discussed in more detail below. *NOTE:* Because the use of induction motors dates back to the early 1900's, and because they are in such widespread use, they are very well standardized. Electrical equipment standards including motors are specified by organizations such as the National Electrical Equipment Manufacturers Association (NEMA) and the Edison Electric Institute. Therefore, many of the things which apply to a motor of one manufacturer, such as dimensional information, will be identical to that of any other manufacturer. If, for example, you were to replace a motor that was constructed with a 445 T frame, this machine would be dimensionally the same as a 445 T frame from a different manufacturer.

Power Supply

Voltage. Motor nameplate voltages will be less than the utility power system voltage because of the following established recommended standard for 60 Hz power systems:

Nominal Power System Volts	Motor Nameplate Volts
208	200
240	230
480	460
600	575

Motors rated 200 horsepower and below will operate at rated load with a voltage variation of ±10 percent of nameplate value. If frequency varies as well, the sum of the voltage and frequency variation should not exceed ±10 percent. In any case, frequency should not vary more than ±5 percent.

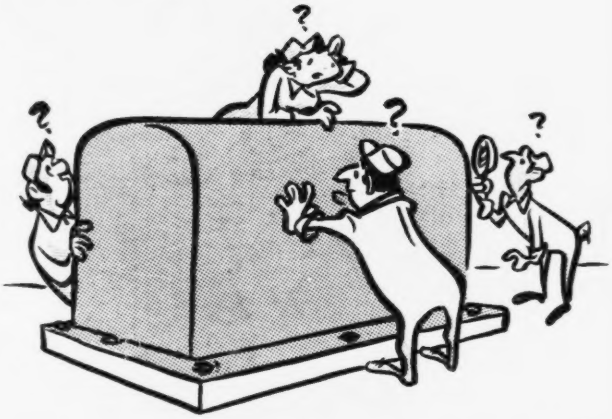
Motor Type

Although there are four designs specified (A, B, C, D), the NEMA design B is most common in wastewater lift stations and is characterized by normal starting torque, low starting current, and low slip. In the case of variable-voltage and variable-speed drives, high-slip NEMA design D motors are generally used and their full load speed is 8 to 15 percent lower than the synchronous speed.

Enclosure

The motor enclosure used depends on the ambient or environmental conditions where the motor is installed and are of two general classifications:

1. Open and
2. Totally enclosed.



An open machine has ventilating openings to permit passage of external air over and around the windings of the motor. A totally enclosed machine is constructed to prevent the free exchange of air between the inside and outside of the motor frame, but is not airtight.

The two general categories of enclosures are broken down further as described in the following paragraphs.

Open Drip Proof (ODP) - The ventilating openings are constructed so that drops of liquid or solid material falling on the motor at an angle of not greater than 15 degrees from the vertical cannot enter the motor directly or by striking and running along the motor frame surfaces.

Open Drip Proof-Fully Guarded - An open motor having all air openings that allow direct access to electrically live or rotating parts, has either limited size openings or has screens to prevent the accidental contact of parts.

Totally Enclosed Ventilated - An enclosed motor which is not equipped for cooling by external means.

Totally Enclosed Fan Cooled (TEFC) - An enclosed motor equipped with an integral fan.

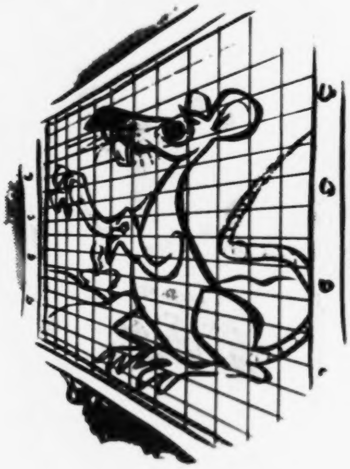
Explosion Proof - An enclosed motor whose enclosure is designed and constructed to withstand an explosion of a gas or vapor if it occurs within the motor and prevent the ignition of the gas or vapor surrounding the motor (hazardous atmospheres are classified by the National Electrical Code).

Motor Windings/Insulation

In certain environments such as very damp or warm weather climates, additional insulation treatment is desirable to improve the ability of the motor insulation to resist moisture. Standard motor insulation will have one or more coats of varnish applied during construction. Additional coats will improve the resistance to moisture. In certain cases, a special insulation system called non-hygroscopic insulation is available; it is made of materials that will not absorb or retain moisture.

Motors can also be selected for hot, humid environments by specifying tropical insulation treatment, including:

1. Use of a higher class of insulation for higher ambient operating temperatures,
2. Special insulating materials such as varnish to prevent fungus growth, and
3. Screens over all air openings on open, drip-proof motors to prevent the entrance of rodents and snakes.



Altitude

Motors depend on the ambient air to remove heat and this heat transfer is a function of air density. Altitude can decrease the effectiveness of this process. Accepted guidelines state that air density has little effect on cooling between sea level and 3300 feet. As a rule of thumb, motor operating temperature will increase one percent for each 330 feet increase in altitude over 3300 feet.

Motor Mounting

There are three types of standardized machine mounting configurations for motors. These allow you to attach pumps or other equipment to the motor.

1. Type C face end shield. Provides a male rabbet and tapped holes for mounting bolts (sump pumps).
2. Type D flange. Has a male rabbet, but with holes for through bolts in the flange.
3. The Type P base. Has a female rabbet and through bolts for mounting in the flange and is used to mount motors in a vertical position.

NEMA Code Letters for Locked Rotor Kilovolt-Ampere

Motor Codes are particularly important when considering the sizing of pump station standby power since it directly relates to the generator's ability to start the motor.

The motor code represents the locked rotor kilovolt-ampere (KVA) per horsepower of the motor and is calculated by the following formula:

$$\frac{\text{KVA}}{\text{HP}} = \frac{1.73 \times 1 \times \text{E}}{1000 \times \text{HP}}$$

The table below lists the letter designation and the KVA per horsepower required:

Letter Designation	KVA Per Horsepower
A	0.00 - 3.15
B	3.15 - 3.55
C	3.55 - 4.00
D	4.00 - 4.50
E	4.50 - 5.00
F	5.00 - 5.60
G	5.60 - 6.30
H	6.30 - 7.10
J	7.10 - 8.00
K	8.00 - 9.00

Typically, lift station motors are Code G or Code H motors.

Internally Thermally Protected Motors

Many agencies require motors to be supplied with internal thermal protection which constantly monitors the winding temperature of the motor. If the temperature is exceeded, a switch, which is connected to the control circuit in the motor control center, opens and stops the motor. (These standard connections are labeled P1 and P2 in the motor conduit box.) The circuit can be wired so that when the motor winding cools down and the thermostatic switch resets, the motor restarts; however, it is preferable to lock the motor out through the control circuit to prevent the motor from restarting until the problem is investigated.

Unless the motor is specially designed, the motor ambient operating temperature should not exceed 40°C (104°F). See Chapter 9, Section 9.26 for more information on Motor Operating Temperatures and Insulation Characteristics.

Service Factor - Service factors greater than 1.0 allow an added margin of safety to account for higher voltage or frequency variations. A 1.0 or 1.15 service factor is usually found on lift station motors. The service factor should not be used for continuous motor overloading which exceeds the nameplate horsepower.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 89.

8.2D Why have bar racks been eliminated or not installed in lift stations pumping only domestic and industrial wastewater?

8.2E What is the purpose of a sump pump in a dry well?

8.2F What happens when a seal fails on a submersible pump?

8.26 Controls

Controls to start, stop or change pumping rates in a lift station are used to tell the pumps when to operate based on the level of the wastewater to be pumped from the wet well. Primary controls such as floats, bubblers or pressure-sensitive devices measure the level of water in a wet well. Secondary controls convert the measurement from the primary controls into a signal for a pump to start, stop, or change speed. These secondary controls convert a sensing signal into a mechanical or electrical signal which, in turn, actuates low voltage motor relays to start or stop motors or milliamp signals to change ranges on variable-speed equipment.

8.260 Float Controllers

Float controllers are one of the oldest methods used to start and to stop pumps or to indicate the level of water surface in the wet well. The float may be a four- to eight-inch diameter ball manufactured from copper or stainless steel, or it may be a flat plate of six to twelve inches in diameter and several inches thick manufactured from copper, stainless steel, or a ceramic material, or it may be a cylinder of six to ten inches in diameter and six to ten inches in depth and made of glass, stainless steel, or a ceramic material. In some instances old brown jugs were used for floats. The jugs were partially filled with sand or lead shot to provide stability and to counteract a portion of the float buoyancy.

All of these devices float on the water surface. When the wet well fills and the water surface rises, the float rises; and as the wet well is pumped down, the float drops with the water surface. The float must be physically attached by steel rods, steel tapes, cables, or ropes to transmit the rise and fall of the float to a recording or signaling device.

A. Rod-attached floats (Figure 8.18)

Ball floats are usually attached to ¼ or ⅜-inch steel rods. The rod is attached to the top of the ball float and extends up to or through the cover of the wet well and passes through the eye of an actuator arm that is connected to a micro switch. The float rod is equipped with brass stops on both sides of the micro switch arm. When the wet well fills, the bottom stop on the float rod pushes the micro switch arm up and starts the pump. When the wet well is pumped down, the float drops and the rod travels downward. When the top stop on the float rod pushes the micro switch arm down, it turns the pump off. The wet well rise and fall levels are selected or changed by moving the rod's stops to new positions on the float rod.

Lowering the bottom stop on the float rod permits a higher wet well water level by starting the pump later. Raising the bottom stop will lower the wet well level at which pumping is started. Once the top stop on the float rod is positioned, it should not be changed because it is set to turn the pump off before it loses suction. If a pump loses its suction and is allowed to operate, the pump could be seriously damaged.

The most common application of ball-type float controllers is on sump pumps and on small wet well lift stations employing only one pump.

B. Steel tape-, cable-, or rope-attached to floats (Figure 8.19)

This type of float is a little more complicated than the rod-attached float. Generally this type of float requires a stilling well for the float to prevent excessive movement of the float. Too much movement of the float will produce incorrect readings. A stilling well is usually a section of pipe ten to twelve inches in diameter which extends several feet above and below the normal wet well operating water level. Usually the stilling well stands vertically in a corner or against a wall of the wet well. The stilling well is open at the bottom or is provided with a smaller inlet pipe of 2.5 to 4 inches in diameter near the bottom to permit water in the stilling well to follow the rise or fall of the water in the wet well.

The float is housed inside the stilling well and is provided one to two inches of free clearance to permit the float to travel up and down the stilling well. At the top of the float is attached the steel tape, cable, or rope that goes up the stilling well, through the cover of the wet well, and is wound onto a small drum which is counterbalanced to maintain tension on the float. When the water in the wet well rises, the float rises and the drum rotates, thus winding in the float tape, cable or rope. This rotation takes in slack in the line attached to the float and keeps the line taut. When the wet well is pumped down, the float lowers and the drum reverses direction, thus unwinding the line attached to the float. When the wet well water level rises, the float rises and the float line is wound onto the drum or sheave. This permits the counter balance to drop and rotate the drum holding the cams and mercury switch (Figure 8.19). When the drum rotates sufficiently to drop the mercury switch from contact with the cam, this allows the mercury to run down to the contact end. When this occurs, the switch closes, the pump motor starter is energized, and the pump starts. When the wet well water level drops, the float drops, reverses drum rotation and unwinds the line attached to the float. If the float drops far enough, the cam on the drum will raise the mercury switch, tilt the switch so the mercury leaves the contact end, opens the circuit and shuts off the pump.

WET WELL RISING

In a multiple-pump lift station, if the first pump cannot handle the wet well inflow, the float will continue rising and at a pre-determined level established by the cam on the drum shaft, the second pump starts (Figure 8.19). If the inflow is greater than the capacity of the two pumps and a third pump is available, the third pump will start next as called for by another cam on the drum shaft. After all pumps available are running and the wet well level continues to rise, the last position on the cam often is used to transmit an alarm signal that the wet well is flooded or wil be flooded soon.

Float controllers are used today for many applications due to their economical cost and ease of maintenance. The floats also provide flexibility by allowing the lift station operator to change lead pumps and pump start-up sequences in a multiple-pump station every week or month or on some other prescheduled frequency. This procedure distributes wear fairly equally on all equipment by a single pump control circuit plug being moved from cam to cam output. Also this procedure could be adjusted so all of the pumping equipment will not wear out at once.[7]

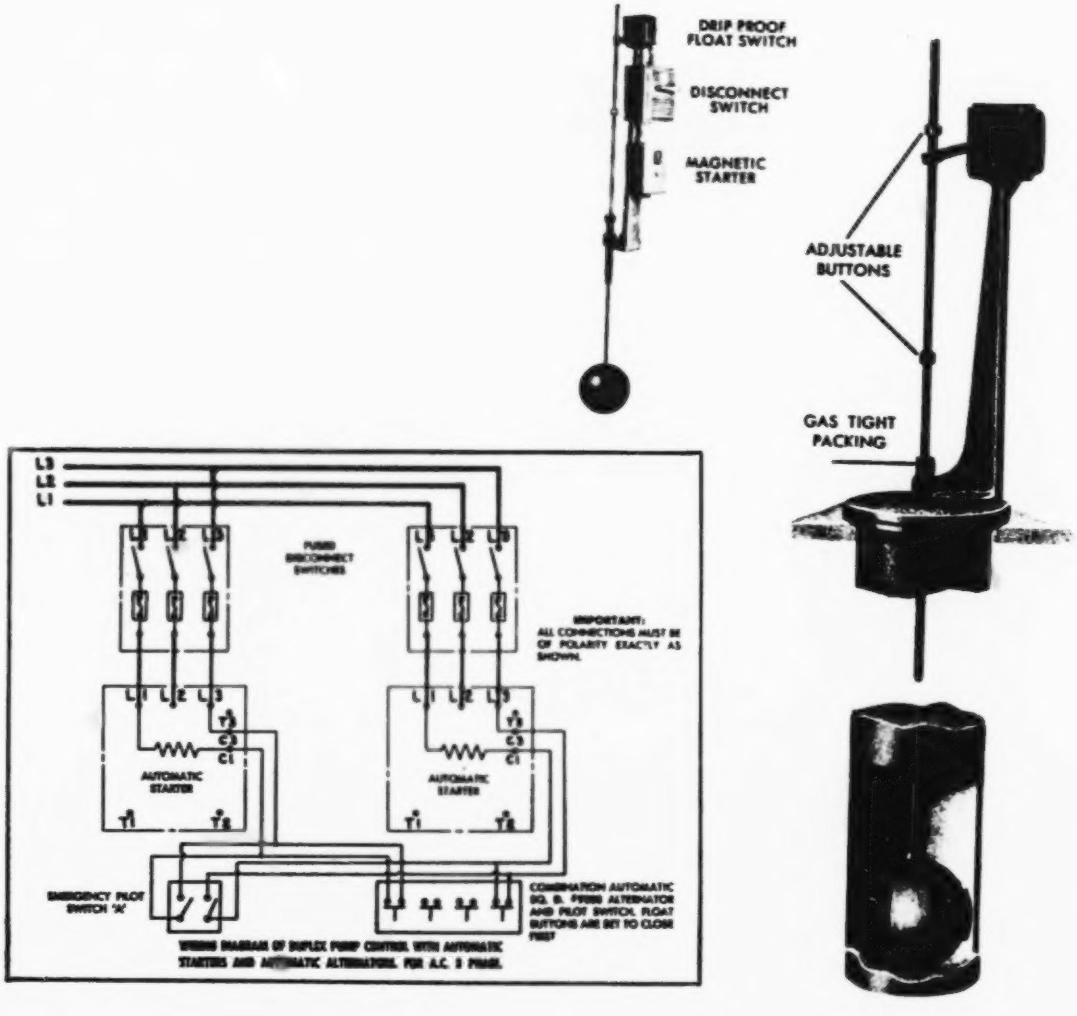

DRIP PROOF FLOAT SWITCH
DISCONNECT SWITCH
MAGNETIC STARTER
ADJUSTABLE BUTTONS
GAS TIGHT PACKING
L3
L2
L1
FUSED DISCONNECT SWITCHES
IMPORTANT: ALL CONNECTIONS MUST BE OF POLARITY EXACTLY AS SHOWN.
AUTOMATIC STARTER
T1
T2
AUTOMATIC STARTER
T1
T2
EMERGENCY PILOT SWITCH 'A'
COMBINATION AUTOMATIC SQ. D. ALTERNATOR AND PILOT SWITCH. FLOAT BUTTONS ARE SET TO CLOSE FIRST
WIRING DIAGRAM OF DUPLEX PUMP CONTROL WITH AUTOMATIC STARTERS AND AUTOMATIC ALTERNATORS. FOR A.C. 3 PHASE.

Fig. 8.18 Rod-attached floats and wiring diagram
(Courtesy of Well Pump Company)

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[7] *"Lift Station Design and Maintenance: Room for Improvement," by Glenn Folk, Deeds & Data, Water Pollution Control Federation, Washington, D.C., June 1975, p. D-1 to 4.*

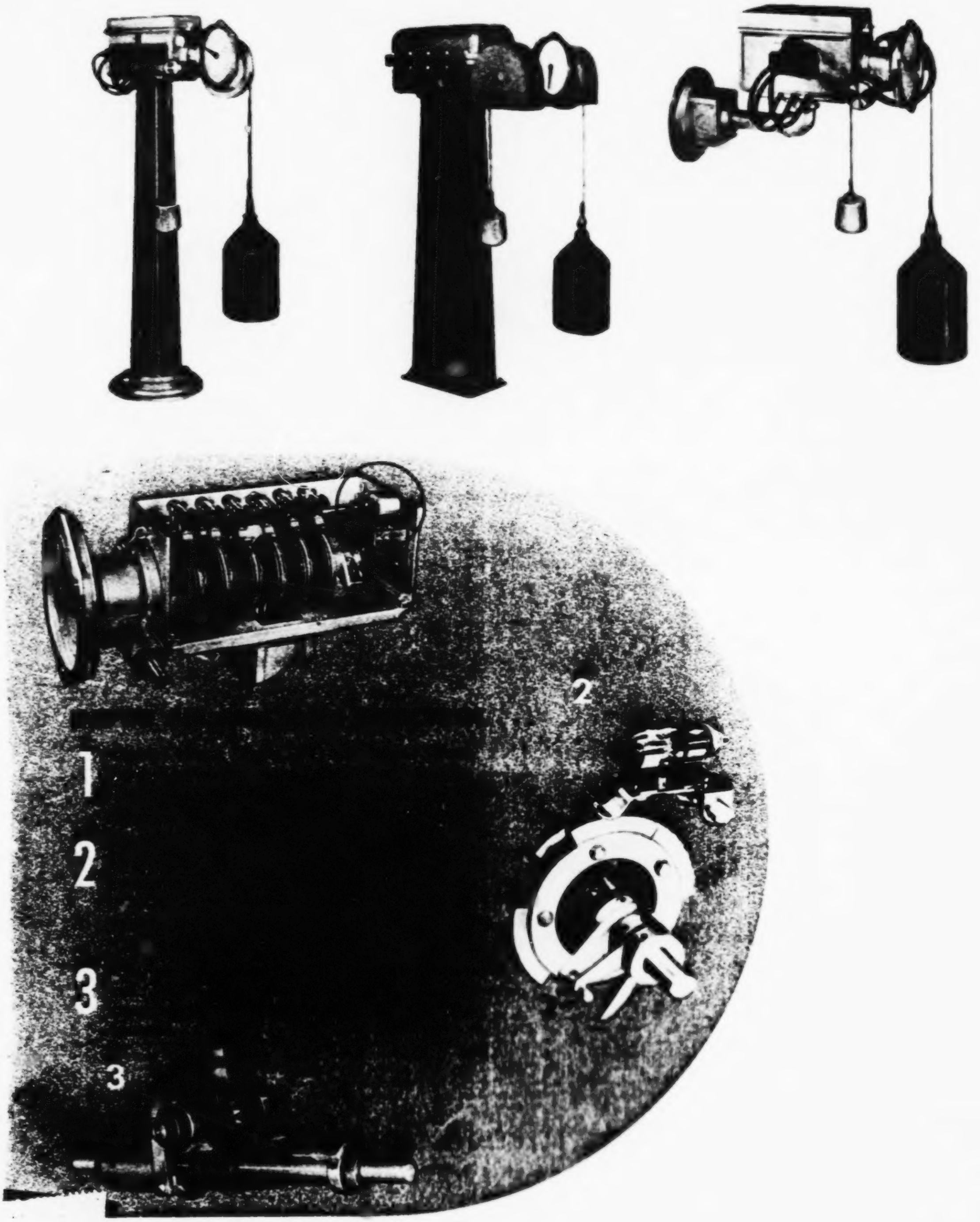


Fig. 8.19 Cable-attached float
(Courtesy of Autocon)

Limitations of float control systems include the following:

1. Grease and debris enter the stilling well and hinder or stop the up-and-down movement of the float. Debris can be removed from the top of the stilling well. Grease can be controlled by running clear water (hot water is better than cold water) into the stilling well at a rate of 1 to 2 gallons per minute to keep the float and stilling well clear of grease and solids. Be sure that this flow of water does not produce false readings of the wet well level unless the openings to the wet well become plugged. Another method of controlling grease is to pour a gallon of kerosene down the float tube and use of a half-moon scraper.

FLOAT CONTROL SYSTEMS
PRO
CON

2. Float attachment line or counterbalance line breaks and unwinds from drum sheave, thus allowing counterbalance to fall and all or none of the pumps could be called on to operate.
3. Floats develop leaks which change or stop pump operation.
4. Cables or ribbons attached to float can become twisted.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 89.

8.2G What are the two types of float controllers?

8.2H. If a float is attached to a rod, what will happen if the top float rod stop is raised?

8.2I What maintenance does a stilling well require?

8.261 Electrode Controllers

Use of this method of control requires that electrodes be installed and maintained in compliance with safety regulations. Be sure that power to the electrodes is turned off and properly tagged before performing any maintenance on the equipment. Operators should be cautioned not to touch electrodes with bar screen rakes and other tools.

The water level sensing or detecting device is simply a weighted electric lead or electrode hanging in the wet well at staggered elevations, usually six to eight inches apart. As the wet well water level rises and submerges an electrode, the water surrounding the electrode completes the control circuit and starts the pump. When the wet well level is pumped down and the electrode exposed to air, it opens the electrical circuit and shuts off the pump. One electrode controls a single pump, and each pump usually has its own electrode. A high wet well elevation electrode is used to indicate flooding of the wet well, and activates an alarm to signal a high water level or flooding.

Limitations of electrode controllers include the following:

1. Rags and debris can wrap around electrodes and alter desired start and stop water levels and sequences of pumps.
2. Grease and/or slime can cover an electrode, thus preventing good conductivity and causing intermittent or unreliable operation.

8.262 Enclosed-Electrode Controllers (Seal trode units)

These controllers are a refinement of the old free floating electrodes. They work in the same manner except they are enclosed in a two to three-inch diameter pipe with a bulb-type container on the bottom end containing an electrolyte solution (Figure 8.20).

Electrodes (one for each pump and a high level alarm) are set at different elevations in the pipe housing. The bulb at the end of the pipe holds from three to eight quarts of electrolyte solution. This volume is sufficient so that water pressure on the outside of the bulb will force the electrolyte solution up the tube to an electrode that completes the circuit and turns on the pump. As the water level in the wet well rises, it compresses the bulb and forces the electrolyte up the pipe to the electrode. When the wet well level is high enough to develop the pressure required to force the electrolyte solution up the tube to the electrode, the circuit is completed and the pump is started. When the water level in the wet well drops, the electrolyte solution also falls and opens the circuit. The electrodes in this system are spaced much closer in elevation (1.5 to 2.0 inches) because the change in water pressure on the bulb is small compared to changes in water depth in the wet well.

Limitations of enclosed electrode controllers include the following:

1. When bulb breaks, electrolyte solution is lost,
2. Shorts occur in electrode wiring, and
3. Bulb life is three to five years.

8.263 Pressure-Sensing Controllers (Air Bubblers)

Air sensing (pneumatic) controllers are being used in many new lift stations being constructed today. They are adaptable to several different control systems and may be used in either simple diaphragm and mercury switches for control inputs, in complex fluidics (air) systems using orifices and chambers to control outputs, or in analog equipment with differential transmitter square root extraction (a method of measuring pressure) and averaging relays that convert signals from pneumatic to electronic (4 to 20 milliamp) outputs for use by controllers and integrators.

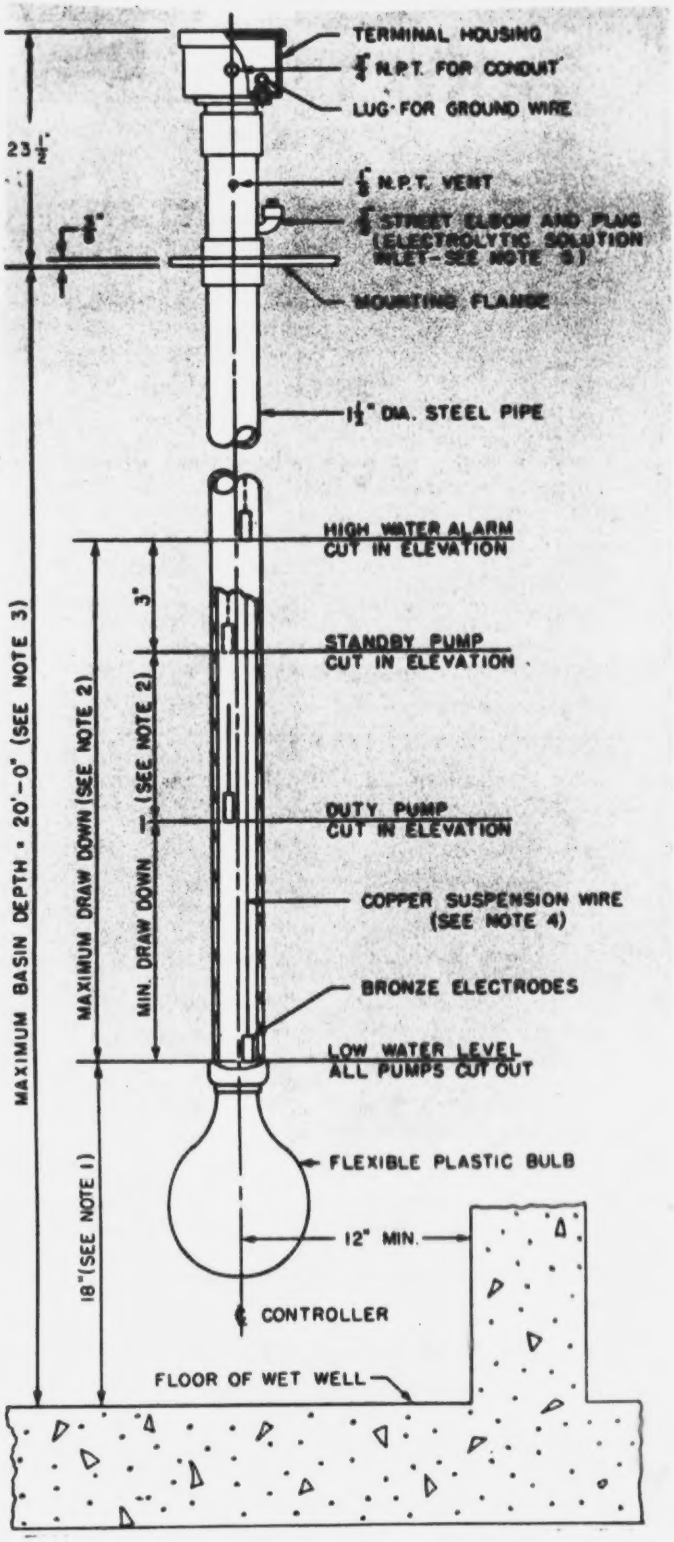

TERMINAL HOUSING
3/4" N.P.T. FOR CONDUIT
LUG FOR GROUND WIRE
23 1/2"
1/8" N.P.T. VENT
1/4" STREET ELBOW AND PLUG (ELECTROLYTIC SOLUTION INLET-SEE NOTE 5)
3/8"
MOUNTING FLANGE
1 1/2" DIA. STEEL PIPE
HIGH WATER ALARM CUT IN ELEVATION
3'
STANDBY PUMP CUT IN ELEVATION
DUTY PUMP CUT IN ELEVATION
COPPER SUSPENSION WIRE (SEE NOTE 4)
BRONZE ELECTRODES
LOW WATER LEVEL ALL PUMPS CUT OUT
FLEXIBLE PLASTIC BULB
12" MIN.
℄ CONTROLLER
FLOOR OF WET WELL
MAXIMUM BASIN DEPTH = 20'-0" (SEE NOTE 3)
MAXIMUM DRAW DOWN (SEE NOTE 2)
MIN. DRAW DOWN (SEE NOTE 2)
18" (SEE NOTE 1)

Fig. 8.20 Enclosed electrode contoller

(Courtesy of Chicago Pump)

ENGINEERING INFORMATION

NOTE 1—18" is the minimum low water level setting for the controller. However, the actual low water setting must be set at a height to keep the pump casing flooded.

NOTE 2—The maximum overall draw down is 7'. The minimum recommended draw down setting is 6" per pump.

NOTE 3—When the basin depth exceeds 20', a 2" steel pipe must be supported by wall brackets.

NOTE 4—Suspension wires in the terminal housing have identifying labels, "A," "B," "C," etc. Wire "A" is attached to the lowest, or pump cut out electrode. Wire "B" is the next lowest, or pump cut in electrode. Wire "C", etc.

NOTE 5—Electrolytic solution consists of a mixture of 3½ quarts of clear water and one package of sodium bicarbonate.

NOTE 6—Organic acids or alcohol should not be used with the Flexible Plastic Bulb. Temperature limitations are 35°F. minimum . . . 140°F. maximum.

NOTE 7—Wires to terminals 3 and 5 must be same phase. Wires to terminals 4 and 6 must be same phase.

Bubblers provide constant, low-volume, low-pressure air through a vertically mounted pipe in the wet well. The bubbler system is aptly named since, when working properly, bubbles can be observed at the surface of the wet well.

The principle of the bubbler system is actually fairly simple. If you have ever blown air through a straw into a glass of water, you know that it requires a certain amount of air pressure to displace the water in the straw and to force air out the bottom of the straw. The amount of force required is determined by the depth of the liquid over the end of the straw. For example, if the depth of the water is 2.3 feet, it will require a pressure of 1 PSI (pounds per square inch) to push the air through the straw and out the bottom. (We know this since 1 PSI is equal to a column of water 2.3 feet high.) Since the air pressure in the straw is directly related to the level of water over the end of the straw, it stands to reason that by measuring the air pressure we can determine the actual water level or depth.

Figure 8.21 illustrates a pneumatic bubbler system which because of its redundancy is extremely reliable. Described below are the individual components of this system.

1. Two-1/6 or 1/12 horsepower air compressors are mounted on a small-ten gallon air receiver tank which acts as an air reservoir. The tank is desirable since it allows the compressors to shut off instead of running continuously. Additionally, in the event of a failure of both compressors, the system would continue to operate because of the reservoir for some period of time (depending on the pressure in the tank).

Note: Tank condensate must be bled off from the tank drain periodically.

2. Pressure in the discharge side of the tank is sensed by two pressure switches which turn the compressor on and off in a lead/lag sequence. If the lead compressor fails, the lag compressor comes on when pressure in the system drops to a lower preset value at the lag pressure switch.
3. A two-inch 0-to-100 PSI gage is mounted in the line so that high pressure air can be monitored.
4. A desiccant-type air dryer (one that uses silica gel as the dehumidifying agent and that can be regenerated) is located in the line to remove moisture and prevent condensation farther downstream in the instrumentation or in the bubbler line.
5. A shut-off valve permits isolation of the high pressure air side from the low pressure air side for maintenance purposes and is in the normally open position during operation.
6. A pressure-reducing valve and a two-inch gage reduce the high pressure from 40 to 80 pounds (PSI) to generally less than 5 PSI (remember that the pressure will be determined by the depth of water in the wet well). Usually this is established by the highest level that can be reached under high wet well conditions. The two-inch gage monitors the downstream or low pressure side of the pressure-reducing valve.
7. An air flow regulator maintains a constant low volume flow of air into the system; typically, one-half to one cubic foot per hour.
8. A zero-to-five PSI pressure transducer senses the pressure in the line and converts the pressure to an electrical signal which is then sent to the motor control center and sequences pumps, alarms, and other supervisory control functions.
9. A low pressure switch is also installed at this point so that a loss of pressure can be sensed and alarmed.
10. A six-inch to 160-inch gage, which is mounted on the supervisor control panel door, reflects actual level in inches in the wet well.
11. The last bleed-off valve shown in the system is in the normally closed position and is used for bleeding off condensation.
12. This particular system incorporates a manual purging panel which allows high pressure blow down of the bubbler pipe in the wet well to clear grease or other accumulated debris from the system.

The advantage of a manual system versus an automatic purging system (which uses solenoid valves) is positive isolation of the low pressure instruments, specifically the pressure transducer, low pressure switch, and gages. Permanent damage to these instruments will occur if they become over-pressurized as might happen with automatic solenoid valves if high pressure air leaks past the seat.

The manual purging panel has quick disconnect pneumatic fittings on the front of the supervisory control. The operator physically removes the bubbler system low pressure side and connects it to the high pressure side.

Bubbler System Maintenance

System maintenance consists of the following tasks:

1. Draining condensation from air receiver weekly or monthly,
2. Changing dryer desiccant,
3. Weekly purging,
4. Weekly checks of pump/alarm sequencing, and
5. Semi-annual checks of bubbler pipe in wet well for corrosion or looseness.

Many pump stations have been flooded when high wet well levels caused flow through the bubbler pipe wall hole and back into the dry well. The hole should be well sealed. If wastewater enters the system, it will damage the instruments. A loop in the bubbler pipe in the dry well *ABOVE* the highest wet well level possible will eliminate back-siphoning-/draining into the system under high wet well conditions. In northern climates during cold weather, if moisture accumulates in the loop it can freeze and cause a plugged bubbler. Do not allow condensate to accumulate.

Symptoms of Plugged or Broken Bubbler

	Wet Well Level	Air Pressure	Pumps
Plugged	minimum	maximum (will indicate a high wet well)	full on - all pumps called for (pumps may be airbound)
Broken or severe air leak	maximum	minimum (will indicate a low wet well)	off - no pumps called for

Many manufacturers and instrumentation companies use pneumatic systems for control. Consult their O&M manuals for your type of equipment and application.

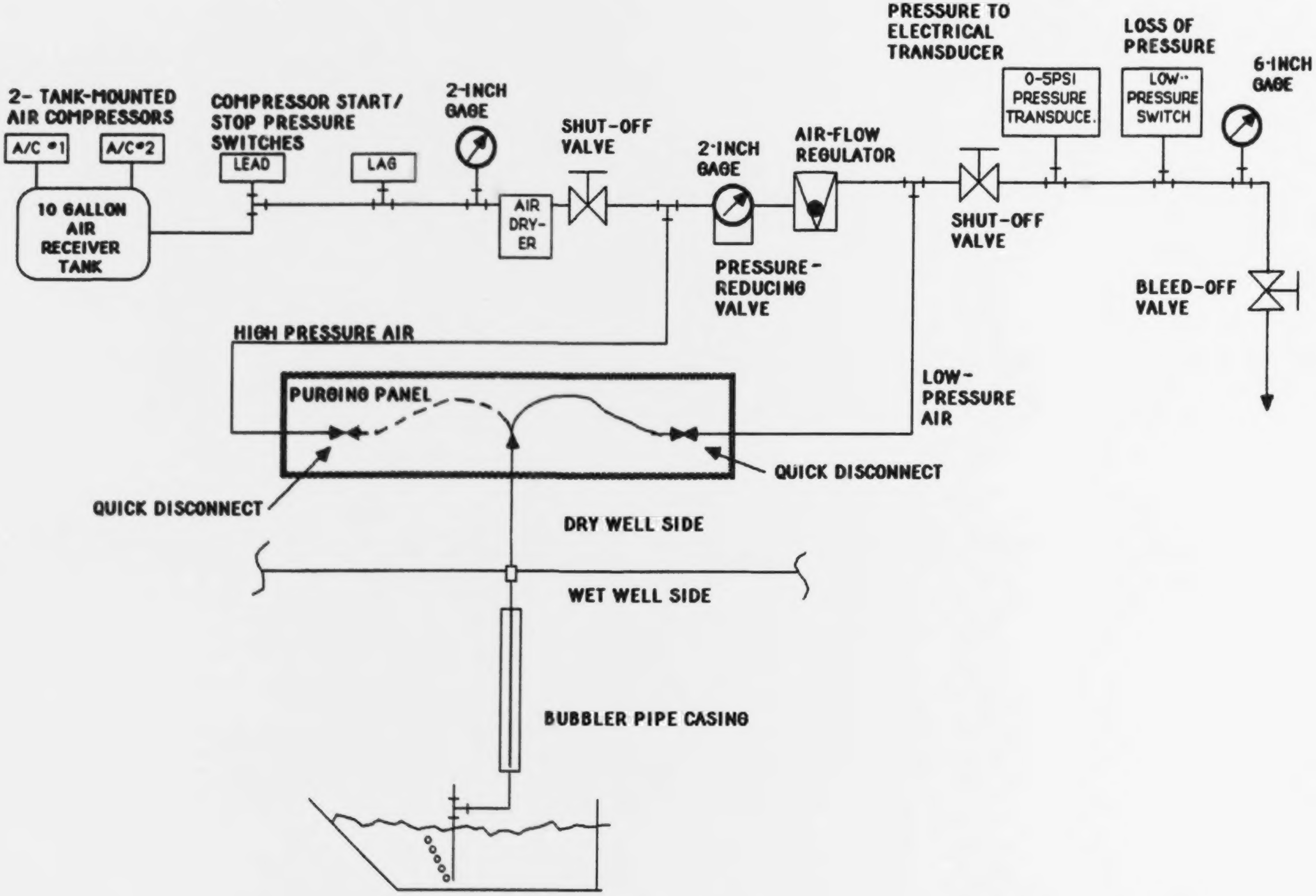

2- TANK-MOUNTED AIR COMPRESSORS
A/C #1
A/C #2
10 GALLON AIR RECEIVER TANK
COMPRESSOR START/ STOP PRESSURE SWITCHES
LEAD
LAG
2-INCH GAGE
AIR DRY-ER
SHUT-OFF VALVE
2-INCH GAGE
PRESSURE-REDUCING VALVE
AIR-FLOW REGULATOR
PRESSURE TO ELECTRICAL TRANSDUCER
0-5PSI PRESSURE TRANSDUCE.
SHUT-OFF VALVE
LOSS OF PRESSURE
LOW-PRESSURE SWITCH
6-INCH GAGE
BLEED-OFF VALVE
HIGH PRESSURE AIR
LOW-PRESSURE AIR
PURGING PANEL
QUICK DISCONNECT
QUICK DISCONNECT
DRY WELL SIDE
WET WELL SIDE
BUBBLER PIPE CASING

Fig. 8.21 Pneumatic bubbler system

Limitations of pressure differential controllers include the following:

1. Air compressor failure,
2. Bubbler blockage (line must be purged regularly), tube breakage, or outlet elevation shifts, and

3. Complex equipment provides more opportunity for failures and requires a higher level of training for operators to troubleshoot, repair and keep instruments calibrated. Often the more reliable an alarm system is, the more complex it becomes and thus the more difficult to maintain because of backup systems.

8.264 Microprocessor-Based Supervisory Controllers

The development of microelectronics has also impacted lift station control systems. Many manufacturers today produce microprocessor-based supervisory controllers, which typically offer the following features:

1. Easily adjustable pump on and off levels,
2. Alternating sequence,
3. Auto/manual functions,
4. Alarms at both high level and low level set points, and
5. Digital readouts of wet well level.

The microprocessor-based systems incorporate small computers into the supervisory control system. They usually receive input from a bubbler-type wet well sensing system that translates air pressure into an electrical signal or from an electronic transducer mounted in the wet well.

These systems are very flexible, easy to adjust and are consistent. Care must be taken, however, in their selection, installation and maintenance since microprocessors are susceptible to voltage surges on the line from lightning strikes, utility company switching and power failures. Figure 8.22 illustrates a microprocessor-based liquid level controller.

8.265 Additional Reading

For additional information on controls, read "A Review of Liquid Level-Sensing Techniques for Indication and Control Purposes." This Review covers 32 different techniques of liquid level sensing. Some do not differ much from others, but in those cases, the differences are considered to be significant or interesting. Obtain the currently free Review from Consolidated Electric Company, 141 South Lafayette Freeway, St. Paul, Minnesota 55107.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 89.

8.2J What types of controls are used to start, stop or change pumping rates?

8.2K What safety considerations are necessary when using electrode controllers?

8.2L What are the limitations of electrode controllers?

8.2M How are pressure changes detected in a pressure-sensing controller?

8.2N What kinds of problems can develop using a seal trode sensing controller?

8.2O How is the depth of water in a wet well measured using a pressure-sensing controller?

8.2P What kinds of problems can occur with pressure-sensing controllers?

8.27 Pumps

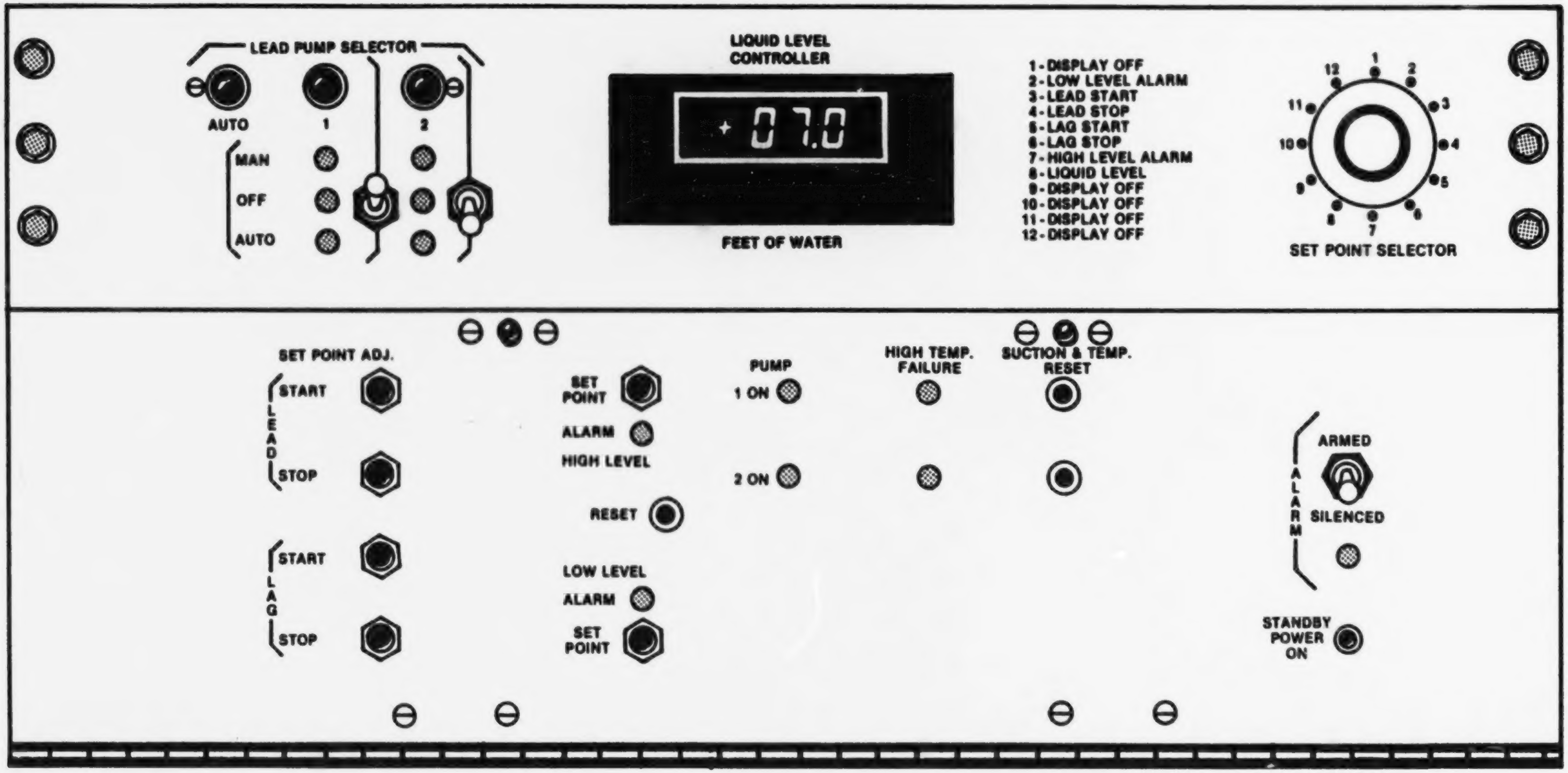
8.270 Centrifugal Pumps

Pumps constitute major pieces of equipment in the lift station, and obviously, one of the most important components. Yet, they remain one of the least understood pieces of equipment in the station. Reliable and efficient pump operation depends heavily on the collection system operator's knowledge and understanding of the principles of operation.

Chapter 9 (Section 9.31 LET'S BUILD A PUMP) can be used as a reference for this section; however, it should be pointed out that the pump in the example is a multi-stage centrifugal pump normally used for clean water applications and is not the type of pump found in a station pumping raw wastewater. The operating principles, however, are generally the same.

By far the most common type of pump found in raw wastewater lift stations is centrifugal; therefore, this section will focus on centrifugal pumps. It is preferable to design pump stations with multiple pumps so that, at any given time, one pump can be taken out of operation for routine, periodic maintenance. Stations must be capable of operating even during peak flow periods with the possibility of one pump being out of service for maintenance; therefore, a station designed for capacity at peak flows will normally have one additional pump sized to handle peak flow pumping requirements. If two pumps are required under peak flow circumstances, the station should have three pumps and so on.

LIQUID LEVEL CONTROLLER


LEAD PUMP SELECTOR
AUTO
1
2
MAN
OFF
AUTO
LIQUID LEVEL CONTROLLER
+ 07.0
FEET OF WATER
1 - DISPLAY OFF
2 - LOW LEVEL ALARM
3 - LEAD START
4 - LEAD STOP
5 - LAG START
6 - LAG STOP
7 - HIGH LEVEL ALARM
8 - LIQUID LEVEL
9 - DISPLAY OFF
10 - DISPLAY OFF
11 - DISPLAY OFF
12 - DISPLAY OFF
12 1 2 3 4 5 6 7 8 9 10 11
SET POINT SELECTOR
SET POINT ADJ.
LEAD
START
STOP
LAG
START
STOP
SET POINT
ALARM
HIGH LEVEL
RESET
LOW LEVEL
ALARM
SET POINT
PUMP
1 ON
2 ON
HIGH TEMP. FAILURE
SUCTION & TEMP. RESET
ALARM
ARMED
SILENCED
STANDBY POWER ON

59

Fig. 8.22 Microprocessor-based liquid level controller
(Courtesy of Gorman-Rupp)

60

Pumps are installed with a piping layout that allows isolation of any pump from the rest of the hydraulic system through suction and discharge isolation valves (discussed later in this chapter). Check valves in the discharge piping for each pump prevent backflow through the pump back into the wet well.

8.271 Pump Layouts

In dry well/wet well types of lift stations, raw wastewater pumps are found in one of the following types of layouts:

1. Flexibly Coupled - In this layout the pump and the motor shafts are connected by a flexible-type coupling, as illustrated in Figure 8.23, which is a horizontal type of centrifugal pump. Figure 8.24 which is a vertically mounted centrifugal pump. Note the adapter between the motor and pump required on the vertical installation.
2. Flexibly Shafted - In this layout the pump normally sits on the bottom floor of the pump station and the motor is separately mounted on an intermediate floor. The pump shaft and the motor shaft are connected by a drive shaft similar to that found in vehicles. Figure 8.25 illustrates the pump layout. The drive shaft would connect to the pump shaft.
3. Close-Coupled - Close-coupled pumps use a standard squirrel cage induction motor with an extended shaft that extends beyond the motor and is used to mount the pump impeller on. The motor, in this case, is mounted directly to the pump through the use of an adapter bracket. Figure 8.26 illustrates a close-coupled pump. Close-coupled pumps are generally used in smaller pump stations, particularly the prefabricated type of "canned" lift stations. The submersible pump is a special configuration of the close-coupled pump in that it also uses an extended motor shaft for the pump shaft in addition to having a waterproof motor capable of submersion.

In addition to these three types of configurations, pumps may either be horizontally or vertically mounted. Generally, pump stations use the vertical pumps since they reduce the size, and therefore, initial construction cost of the station. The vertical pump configuration requires sufficient room to remove the pump and rotating element from the volute, as well as room for the lifting device such as a winch or come-along on the ceiling. During the design review stage of lift stations, be sure there is a lifting device for the pumps and enough space to remove the pump and rotating element from the volute.

The principle of operation of all three layouts remains the same. The only significant differences are the mounting method and the method in which the torque is transmitted from the motor to the pump rotating element.

8.272 Pump Components

Figure 8.27 illustrates a nonclog, centrifugal, vertical raw wastewater pump which could be found in a lift station. The particular pump illustrated could be used as a flexibly coupled pump with the addition of an adapter bracket to support the motor or a shafted pump which would use a drive shaft between the pump and the motor. Components of the pump are described in the paragraphs below.

Item 1. This is a drilled, tapped hole which allows the insertion of an eye bolt to facilitate removal of the pump power frame and rotating element from the permanently mounted volute. This allows removal of the entire pump power frame and rotating assembly, including the impeller, without disturbing the suction and discharge piping or the pump base.

Item 2. External shaft adjustment - Raw wastewater pumps, in particular, are subject to wear between the bottom of the impeller and the bottom of the volute. Clearance must be maintained to a few thousandths of an inch (generally 0.0015 inch or less), depending on the manufacturer. If this clearance is allowed to open up, rags and other debris may be caught between the rotating impeller and the stationary volute. When this happens, pump efficiency is lost since recirculation takes place. Not all of the flow being discharged from the rotating impeller goes into the discharge pipe, but rather, some of it recirculates back around to the suction and the impeller eye.

Most pump manufacturers offer replaceable wear rings for both the impeller and the casings (see Figure 8.28) which can be replaced as wear takes place. In addition, some method of adjustment of the clearances is generally provided on the outside of the pump. In this pump, jack screws are provided so the adjustment can be accomplished externally. In some pump designs it is necessary to remove the upper bearing cap and shim underneath the bearing cap to vary the clearances.

Item 3. Double Row Thrust Bearings - Normally, in this type of design, the upper pump bearing in the power frame is a thrust bearing (can accommodate vertical thrust along the axis of the shaft), which can accommodate both upward and downward thrusts created by the weight of the shaft and the impeller and thrust developed by hydraulic forces when the pump is operating. The lower bearing in the power frame is a radial-type bearing which is designed to accommodate radial thrust loads that occur perpendicular to the shaft (sideways thrust). If a pump is operating normally, radial thrust loads are usually small; however, the bearings are generally designed to accommodate unusual circumstances which would increase radial thrust such as occasional plugging or unbalance in the impeller. The majority of bearings in pumps are regreaseable and fitted with zerk fittings.

Item 4. In some cases, a shield is provided at this point to provide isolation of the bearing from water spraying out of the stuffing box and is referred to as a slinger.

Item 5. Leakage Accumulator Gland - This may or may not be a standard feature depending on manufacturer.

Item 6. Packing Box - The stuffing box area of centrifugal pump provides isolation between the liquid end of the pump and the atmosphere, and may use one of two different methods of sealing; packing or mechanical seals. Both types of sealing methods have advantages and disadvantages.

Packing

A stuffing box that uses conventional packing is characterized primarily by the slow, continuous leakage at the top of the stuffing box which is necessary to provide lubrication between the stationary packing and the rotating shaft element. Packing material can be graphite asbestos, teflon, or some other braided material.

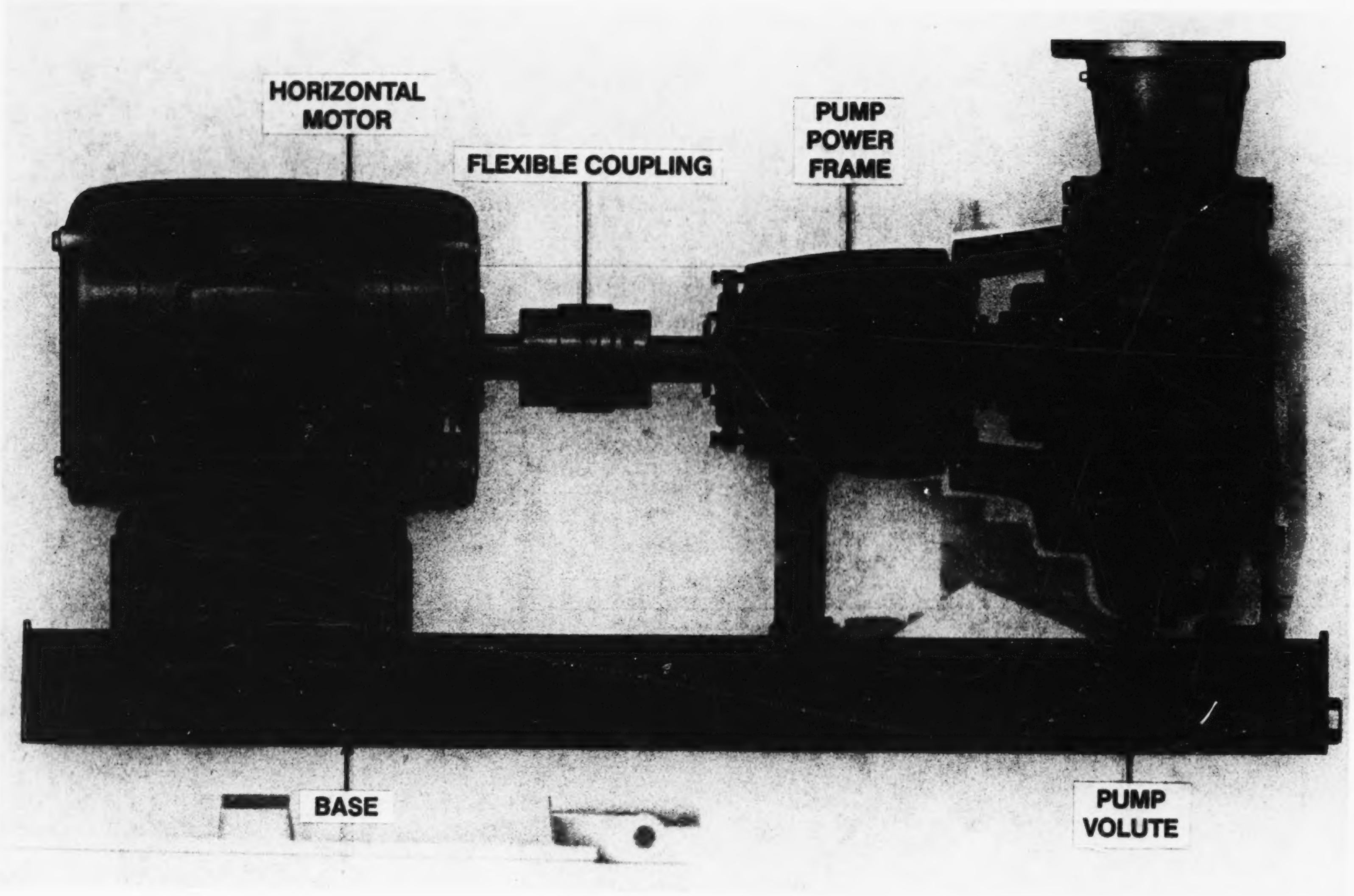

HORIZONTAL MOTOR
FLEXIBLE COUPLING
PUMP POWER FRAME
BASE
PUMP VOLUTE

Fig. 8.23 Flexibly-coupled, horizontally-mounted centrifugal pump

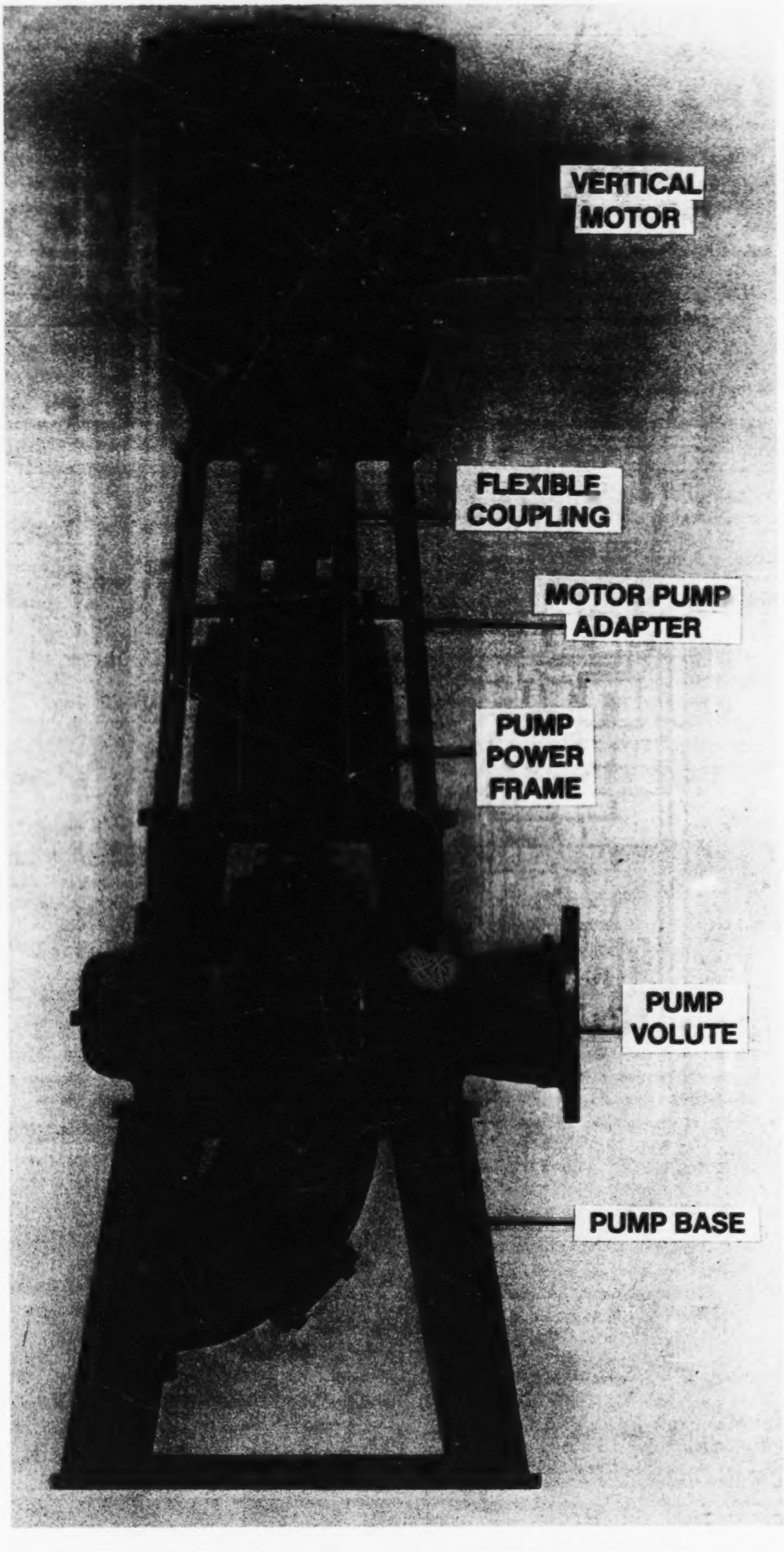

VERTICAL MOTOR
FLEXIBLE COUPLING
MOTOR PUMP ADAPTER
PUMP POWER FRAME
PUMP VOLUTE
PUMP BASE

Fig. 8.24 Flexibly-coupled, vertically-mounted centrifugal pump

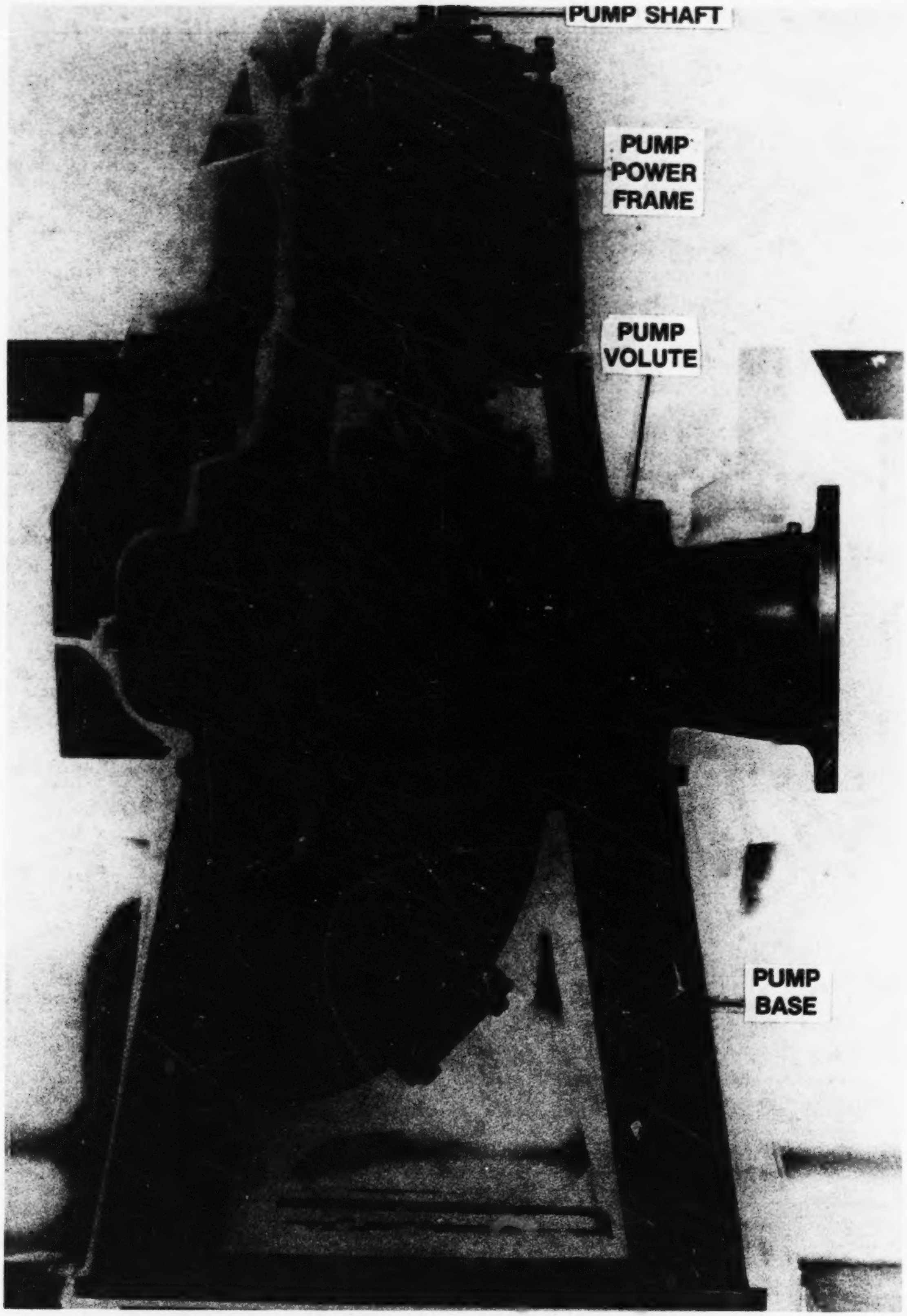

PUMP SHAFT
PUMP POWER FRAME
PUMP VOLUTE
PUMP BASE

Fig. 8.25 Flexibly shafted vertical pump

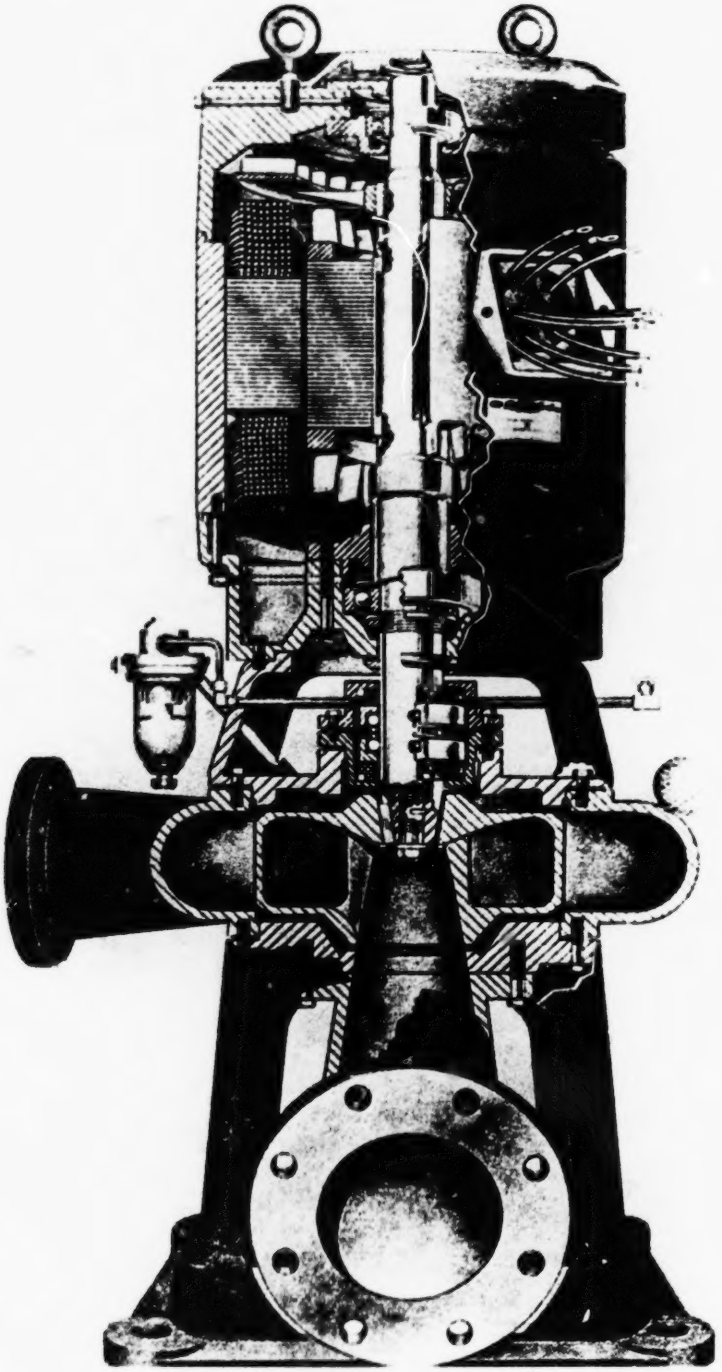


Fig. 8.26 Close-coupled motor pump

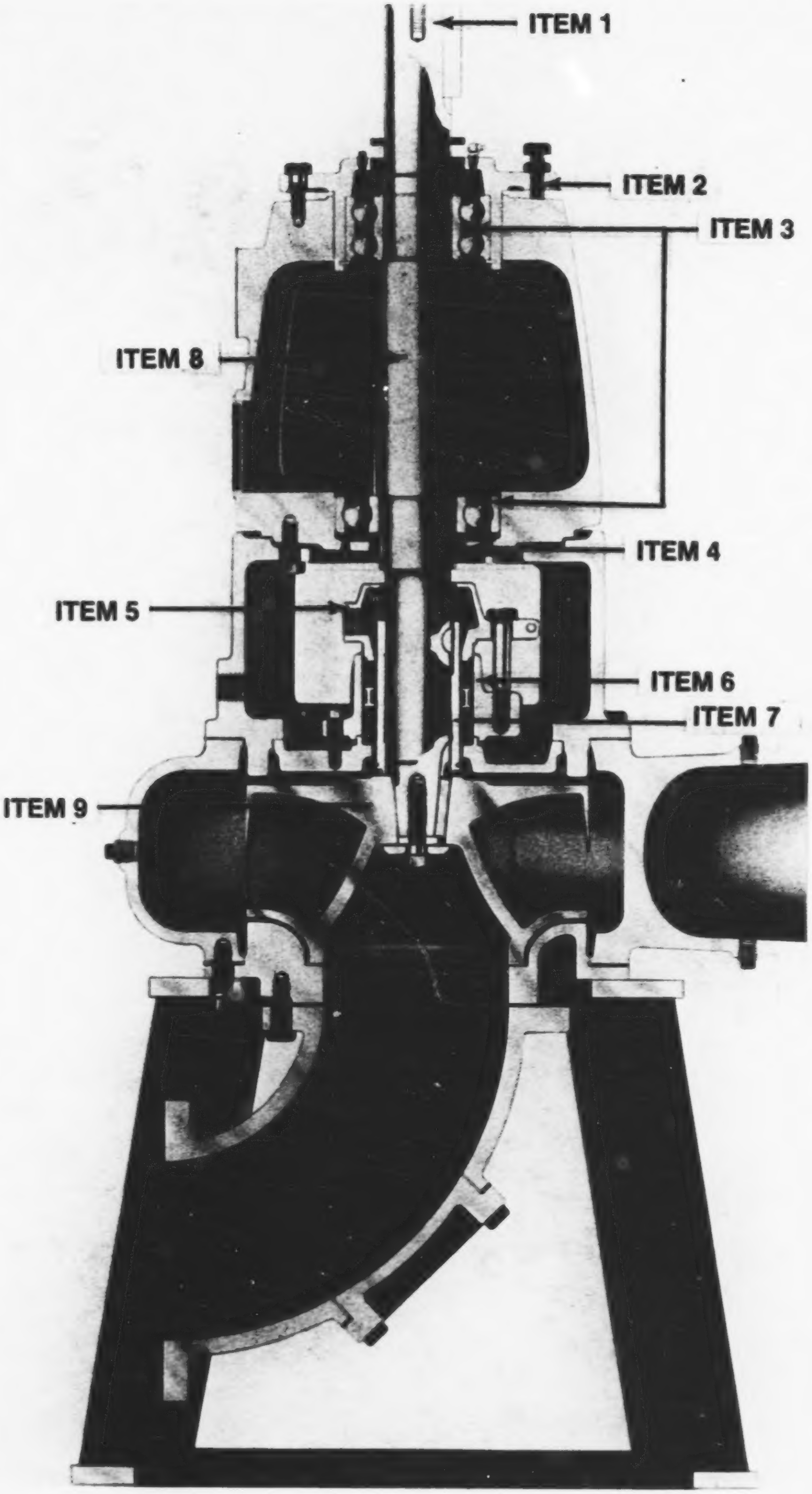

ITEM 1
ITEM 2
ITEM 3
ITEM 8
ITEM 4
ITEM 5
ITEM 6
ITEM 7
ITEM 9

Fig. 8.27 Typical nonclog, vertical, raw wastewater centrifugal pump

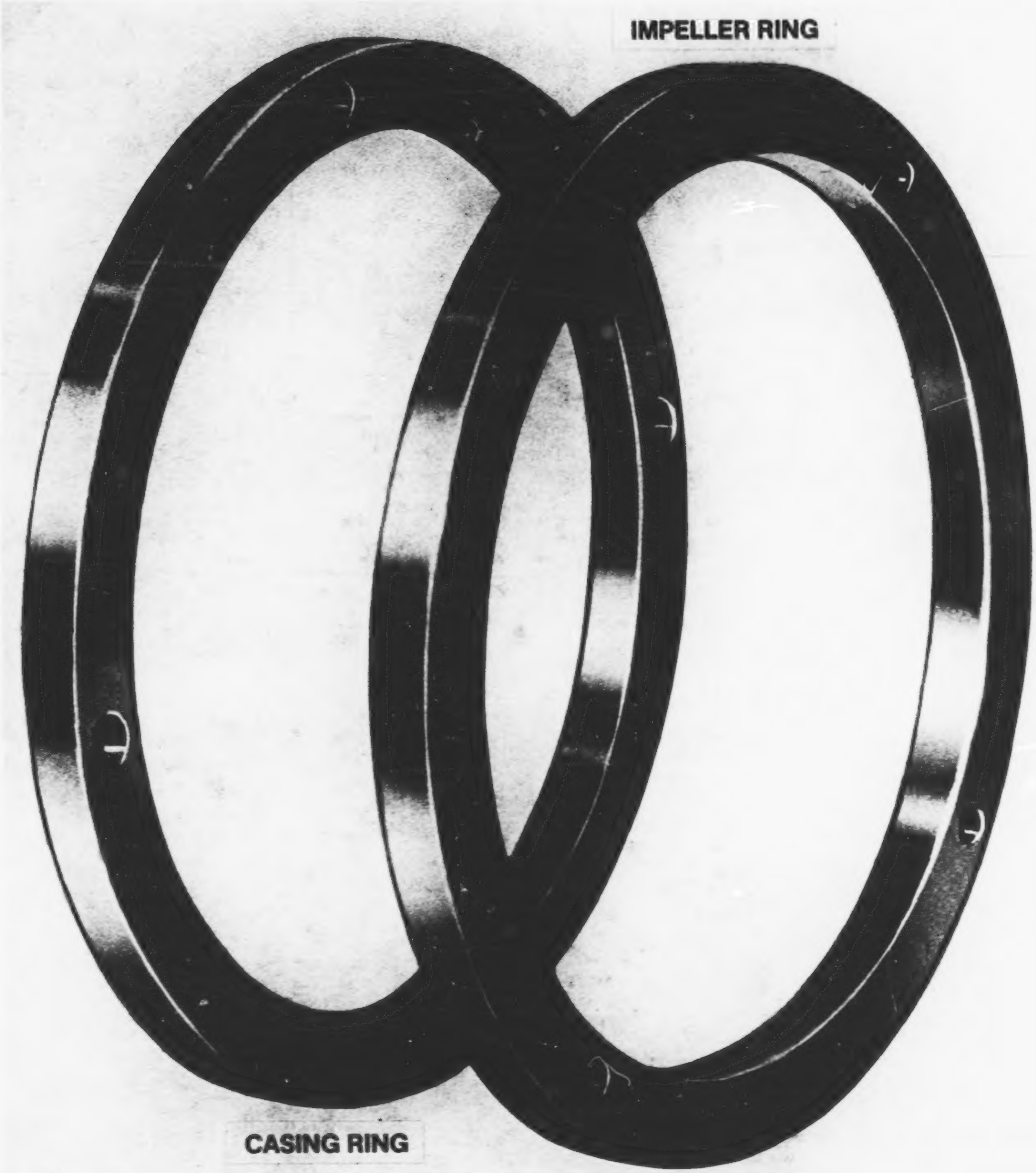
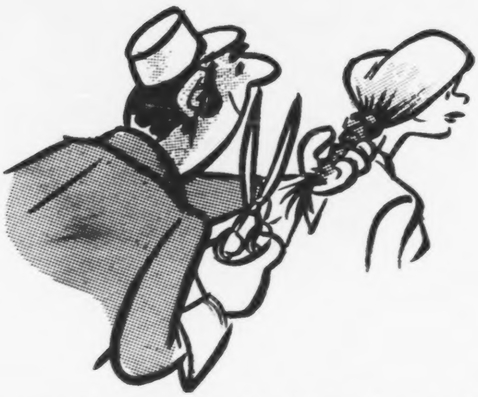

IMPELLER RING
CASING RING

Fig. 8.28 Wear rings



Some manufacturers have discontinued the manufacture of graphite asbestos packing because of current health concerns over asbestos; however, the asbestos in that type of packing is "bound" into the material as opposed to free asbestos. There is little danger to the health of operators in the use of graphite asbestos packing.

A lantern ring is usually installed in the stuffing box. This is a perforated metal or plastic perforated ring, completely surrounding the shaft that provides distribution of water into the stuffing box when an external water source is used as a method of lubrication. In the case where pumps are pulling a suction lift (where the normal water level of the wet well is below the center line of the impeller), the water distributed throughout the lantern ring serves the important function of providing a seal between the atmosphere and the liquid end of the pump. If this were not the case, air would be sucked into the volute and the pump would be unable to maintain a prime.

Stuffing boxes that use packing require frequent adjustments so that the amount of leakage through the top of the stuffing box is minimized, yet, will provide adequate lubrication. Packing can also harden during long use and require replacement. When it loses its flexibility, it loses therefore, its ability to seal the stuffing box area. When packing replacement is required, it is necessary to remove the old packing and install new rings of packing.

The alignment of the lantern ring must be maintained if an external water supply is used so that water continues to be distributed evenly throughout the stuffing box and the shaft.

The top of the stuffing box is called a gland and is normally held in place by adjustable cap screws. These screws allow the operator to increase the amount of pressure the gland exerts on the packing as well as remove the gland to install new packing.

A desirable feature of stuffing boxes is that they be manufactured in two parts or split (see Figure 8.29). This simplifies the job of packing replacement and permits shaft inspection at the point where the packing makes contact with the shaft or shaft sleeve.

Collection system operators must understand that the use of conventional braided packing requires that the stuffing box area clearances be maintained in terms of wear, surface roughness, or other factors which will affect the lift of the packing and its ability to seal. For example, if the lower pump bearing allows radial movement, or if the shaft deflection occurs at the stuffing box, the packing will be "pounded" each time the shaft rotates and will lose its ability to seal effectively. Surface roughness on the stuffing box also affects the ability to seal. If the clearance between the liquid end and the bottom of the stuffing box is excessive, as pressure is applied to the gland, packing can be extruded into the pump area requiring more frequent replacement of packing and reduced ability of the packing to seal the stuffing box area.

Packing Advantages

1. Over the short term, packing may be less expensive than a mechanical seal; however, over the long run, when labor and material costs are considered, this may not be the case.
2. Pumps can generally accommodate some mechanical looseness from bad bearings, tolerances, or clearances in the stuffing box area. Under these circumstances, however, more frequent replacement/adjustment of the packing will be required.

Packing Limitations

1. Increased wear on the shaft or the shaft sleeve.
2. Continuous leakage of raw wastewater used as the lubricating method or clean water to the atmosphere which requires increased housekeeping. If the seal water comes from a domestic water supply, there must be an "air gap" between the domestic supply and the seal water piping to prevent contamination of the public water supply from backflows.
3. Increased labor required for adjustment and replacement of packing.

Mechanical Seals

A second method of sealing the stuffing box area is a mechanical seal, the most common being the double mechanical seal with two sealing areas (see Figure 8.30). Double mechanical seals consist of the following components:

1. A stationary ring inserted into the lower part of the stuffing box and held in place by o-rings. Typically, this is a carbon graphite material.
2. A rotating element installed on the shaft using o-rings to secure the element to the shaft which then rotates with the shaft. This element is normally ceramic and may have some type of hardened metal material on the face. Both the stationary element and the rotating element have very highly polished faces, which contact each other through a very thin film of lubricating liquid, usually clean water. As the shaft rotates, it is the interface between the rotating and the stationary elements which provides the method of sealing. In a double mechanical seal the rotating and stationary elements are duplicated at the top of the stuffing box, but reversed.
3. The next element is a compressed stainless steel spring which exerts a continuous pressure against the upper and lower rotating elements and maintains a positive pressure of the rotating faces against the stationary faces.

   Most mechanical seals are not designed to run dry since they use water for lubrication and to dissipate heat generated at the faces of the seal. The fluid must be clean since any abrasive material introduced into the stuffing box would cause rapid wear and premature seal failure. Water may be supplied from an external clean water source such as a utility's drinking water system or a well. An appropriate backflow-prevention device or air gap must be installed to prevent contamination of the clean

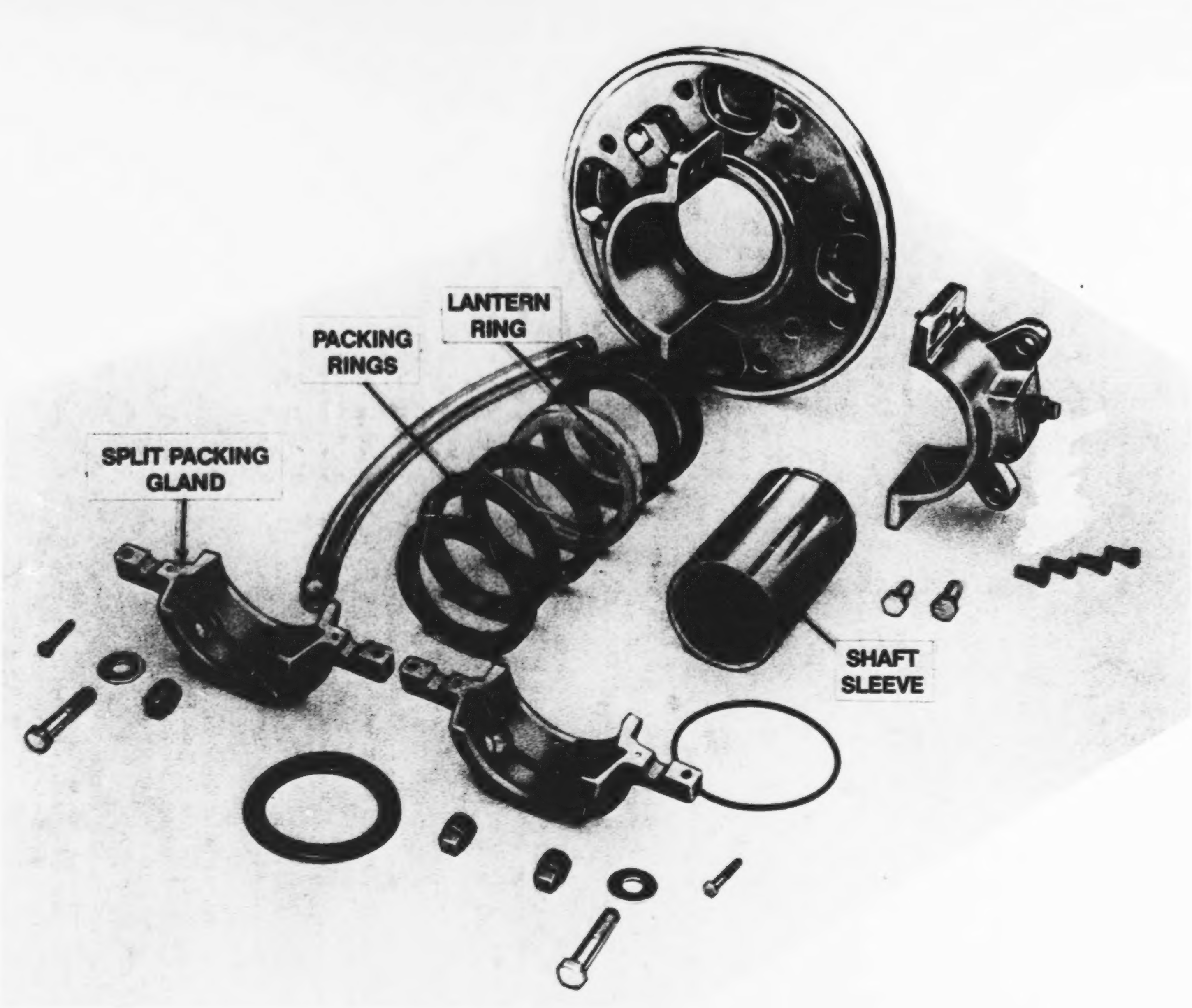

LANTERN RING
PACKING RINGS
SPLIT PACKING GLAND
SHAFT SLEEVE

Fig. 8.29 Split packing box

water source with raw wastewater in the event of a seal failure. Filtered raw wastewater piped from the pump discharge through a filtering mechanism into the stuffing box area is common. Most seals must be lubricated at all times when the pump is operating.

Advantages of Mechanical Seals

1. Mechanical seals are virtually maintenance free with no adjustment required or normally available,
2. Leakage of raw wastewater into the pump station out of the top of the stuffing box is eliminated,
3. Less wear on the pump shaft or shaft sleeve,
4. Less power consumption, and
5. When installed and operated properly, mechanical seals will last for several years before replacement is required.

Disadvantages of Mechanical Seals

1. Initial cost is significantly higher than conventional packing and can range from several hundred to several thousand dollars, depending on the size, and
2. Require more skill and care by the operator when replacing.

Item 7. Shaft Sleeve - A desirable feature of a raw wastewater pump is a replaceable shaft sleeve which is keyed to the shaft in the stuffing box area. This allows for replacement of the sleeve rather than the entire pump shaft when wear occurs in the stuffing box area because of packing. Under certain circumstances wear will occur when using mechanical seals, particularly if the lower seal face fails, thus allowing raw wastewater to fill the stuffing box.

Different types of corrosion and pitting of the shaft sleeve can also occur even when the seal is operating normally, so that when seal replacement is required, it may be necessary to replace the shaft sleeve or resurface it in order to provide a positive sealing surface for the rotating element o-rings. Shaft sleeves may be manufactured from brass, hardened stainless steel (440 series), or conventional stainless steel (316 series). It is also possible in some cases to have local machine shops manufacture shaft sleeves with customized coating such as ceramic or other hardened metal materials through flame spray technology.

This method of manufacture uses a base material such as brass for the sleeve. The shaft sleeve is slightly undercut and then either molten ceramic or hardened alloy is sprayed on to the surface.

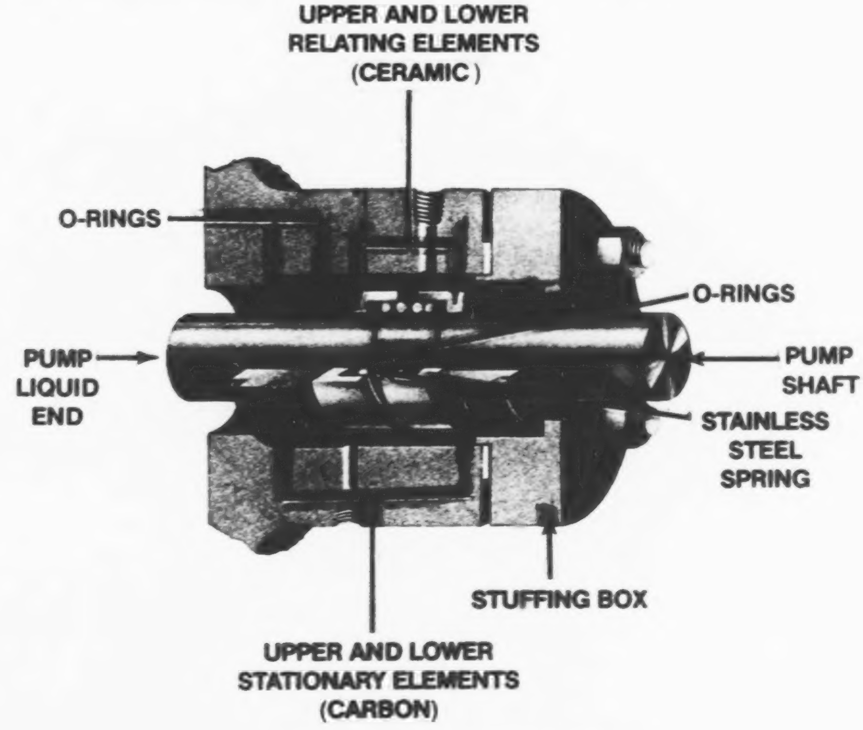

UPPER AND LOWER RELATING ELEMENTS (CERAMIC)
O-RINGS
O-RINGS
PUMP LIQUID END
PUMP SHAFT
STAINLESS STEEL SPRING
STUFFING BOX
UPPER AND LOWER STATIONARY ELEMENTS (CARBON)

Fig. 8.30 Mechanical seal

The sleeve is then machined and polished. Ceramic material is frequently used in pumps with conventional packing since it significantly increases the life of the shaft sleeve. Polished hardened alloys are used with mechanical seals since the polished surface provides a positive sealing method between the o-rings used for the installation of the rotating element portion of the mechanical seal.

Item 8. Shaft - Two key elements of the pump shaft are adequate size to prevent breaking, and a tapered end (which most manufacturers use) where the impeller attaches to the shaft. Shaft dimensional tolerances must be maintained because of critical clearances at the upper and lower bearing, the stuffing box area and the tapered portion at the impeller end. The shaft must be carefully handled during pump assembly and disassembly to prevent damage which would cause the shaft to deflect; for example, 0.002 inches of deflection is the maximum limit at the stuffing box for long packing and mechanical seal life.

Item 9. Impeller - Raw wastewater pump impellers are designed with very large openings at the eye of the impeller passages and discharge areas in order to pump solids in the wastewater. Each pump should be equipped with a bottom *VOLUTE*[8] drain valve and line to the sump and a top or middle volute access inspection port for cleaning the pump. Large horizontal pumps should have a vent valve on top of the volute for priming purposes.

8.273 How to Read and Understand a Centrifugal Pump Selection Curve

Operating and maintenance problems in pump stations are frequently the result of the operator's inability to understand centrifugal pumps. They are basically simple machines that do not require extensive technical knowledge to understand and interpret their operation.

The first step in understanding centrifugal pumps is to understand a pump selection curve and, at first glance, this appears to contain a lot of confusing information (refer to Figure 8.31).

Explanation of Pump Curve on a Step-by-Step Basis

- **Pump Size** - Centrifugal pumps normally are defined by three dimensions; pump suction size, pump discharge size, and the pump volute size, all measured in inches. In this case, this pump is an 8 x 8 x 15A where the first 8 indicates a discharge size in inches, the second 8 indicates suction size in inches, and the 15 indicates volute size which is frequently related to the maximum impeller diameter that can be installed in this pump. (The A indicates a design modification from the original 8 x 8 x 15)

- **Operating Speed** - Operating speed is a function of the motor RPM. The same pump can be operated at different RPM's to give different operating characteristics depending on motor or engine RPM.

8-8-15A
ENGINE RPM
4" DIAGONAL SPHERE

- **Solids Handling Capability** - This indicates the approximate solid size which will pass through the impeller without plugging the impeller. In this case, it is a 4-inch diameter sphere.

- **Impeller Pattern Number and Case Pattern Numbers** - These are numbers used by the manufacturer to indicate the pattern numbers used when casting the different parts.

- **Operating Area** - All centrifugal pumps have a recommended operating envelope (or range) as indicated by the solid bold line on the pump curve. Operation outside of this envelope could cause mechanical damage to the pump components, such as bearings, or cause the pump to operate at excessive levels of vibration.

- **Minimum Impeller Diameter** - This indicates the minimum size impeller which can be installed in the pump. Normally this is a function of operating efficiencies and other design features in the pump.

- **Total Dynamic Head (TDH)** - The vertical scale on a pump curve indicates the total dynamic head, usually in feet, although, as shown on this curve, it can also be converted to meters. The total dynamic head is really a pressure measurement and can be converted to pressure in PSI by using the following conversion factor:

  1 Pound per square inch (PSI) equals 2.31 feet of head (ft)

- **Capacity** - The horizontal scale on the curve indicates the flow capacity in gallons per minute (GPM). If using the metric system, this could also be expressed in liters per second (L/S) or cubic meters per hour (cu M/hr).

- **Efficiency** - As with an electric motor or the engine in your car, the efficiency of the pump is a function of several items and can vary. In this case, the efficiency ranges from 50 to 82 percent, depending on where the pump is operating.

- **Brake Horsepower (BHP)** - Brake horsepower is the horsepower required at a given point in order to pump the flow at a given head.

- **Net Positive Suction Head (NPSH)** - Net positive suction head is an indication of the pump's ability to draw water

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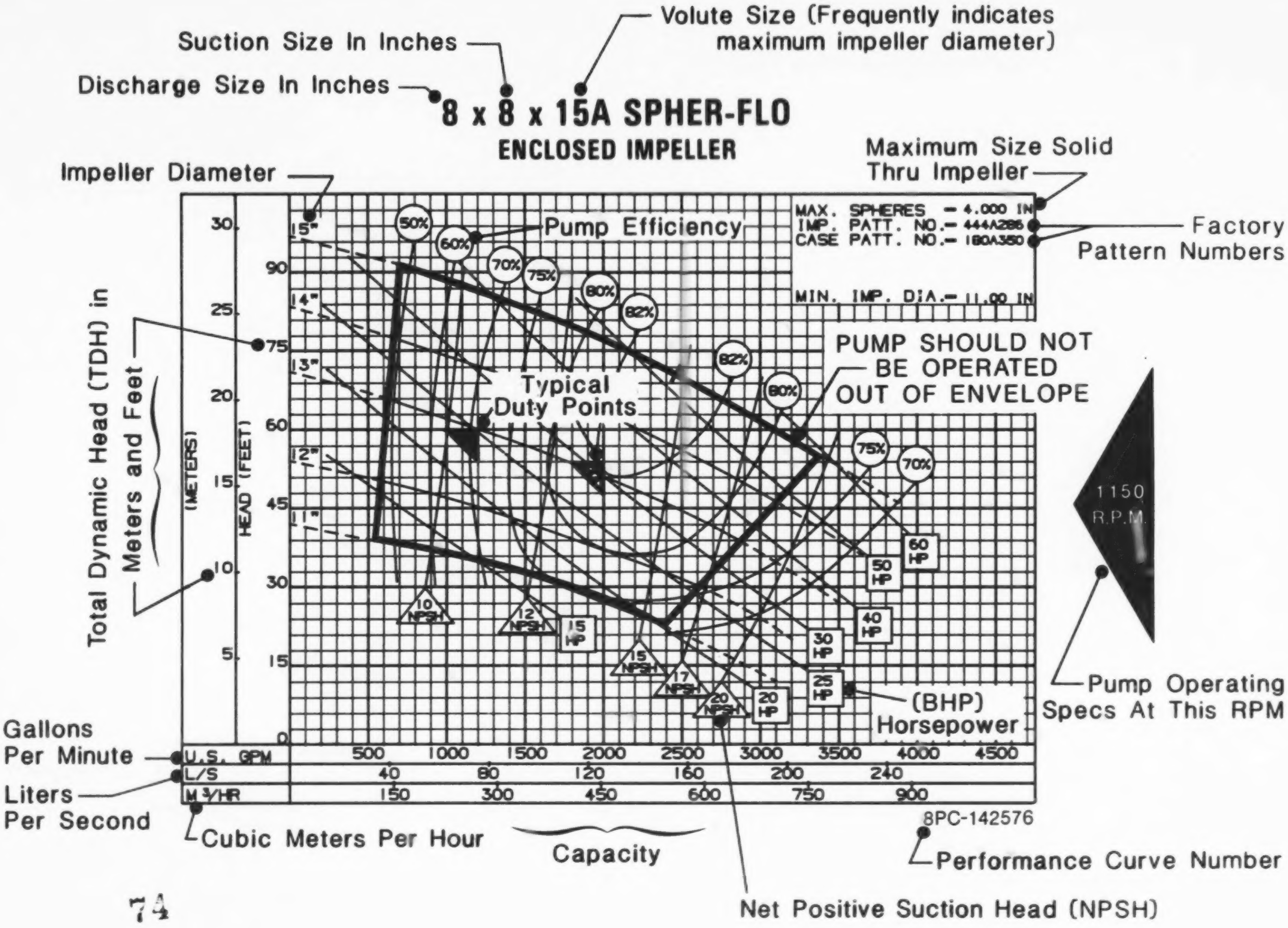
[8] *Volute (vol-LOOT). The spiral-shaped casing surrounding a pump impeller that collects the water discharged by the impeller.*


Suction Size In Inches
Volute Size (Frequently indicates maximum impeller diameter)
Discharge Size In Inches
8 x 8 x 15A SPHER-FLO
ENCLOSED IMPELLER
Maximum Size Solid Thru Impeller
Impeller Diameter
Pump Efficiency
Factory Pattern Numbers
MAX. SPHERES = 4.000 IN
IMP. PATT. NO.= 444A286
CASE PATT. NO.= 180A350
MIN. IMP. DIA.= 11.00 IN
15"
14"
13"
12"
11"
50%
60%
70%
75%
80%
82%
82%
80%
75%
70%
Total Dynamic Head (TDH) in Meters and Feet
(METERS)
HEAD (FEET)
30
25
20
15
10
5
0
90
75
60
45
30
15
Typical Duty Points
PUMP SHOULD NOT BE OPERATED OUT OF ENVELOPE
1150 R.P.M.
Pump Operating Specs At This RPM
10 NPSH
12 NPSH
15 NPSH
17 NPSH
20 NPSH
15 HP
20 HP
25 HP
30 HP
40 HP
50 HP
60 HP
(BHP) Horsepower
Gallons Per Minute
U.S. GPM
500
1000
1500
2000
2500
3000
3500
4000
4500
Liters Per Second
L/S
40
80
120
160
200
240
M³/HR
150
300
450
600
750
900
Cubic Meters Per Hour
Capacity
8PC-142576
Performance Curve Number
Net Positive Suction Head (NPSH)

into the volute and the eye of the impeller. On a pump curve this is indicated as a number expressed in feet and reflects the amount of NPSH required (NPSHR). During the design stage of the pump station, the engineer must calculate the NPSH available (NPSHA). The NPSH available in the pump station must be greater than the NPSH required by the pump at the selected operating point or cavitation is likely to occur.

Operators can use the pump curves to determine the proper operating ranges for their pumps and to compare actual efficiency with expected efficiency. If you know the actual pumping capacity in gallons per minute (GPM) and total dynamic head (feet) of your pump, you can determine if you are operating within the envelope and the expected efficiency. If the pump in Figure 8.31 is pumping 2000 GPM against a total dynamic head (TDH) of 60 feet, then the pump efficiency should be about 82 percent. Find 2000 GPM across the bottom of the drawing and then move upwards until this vertical line intersects with the horizontal 60-foot TDH line from the left side of the drawing. At the point where these two lines intersect is where the pump efficiency is read from the pump efficiency curves (about 82%). The brake horsepower (BHP) is between the 30 HP and 40 HP lines at about 36 BHP. The water horsepower (WHP) can be calculated from the following formula:

$$\text{WHP} = \frac{(\text{Flow, GPM})(\text{TDH, ft})}{3960}$$

The pump efficiency can be calculated by the following formula:

$$\text{Pump Efficiency, \%} = \frac{(\text{WHP})(100\%)}{\text{BHP}}$$

If the calculated pump efficiency does not agree with the value from Figure 8.31, then there could be some problems with the pump operation.

The wire-to-water efficiency is the efficiency of the electrical input in terms of pumping water.

$$\text{Wire-to-Water Efficiency, \%} = \frac{(\text{WHP})(0.746\text{ Kilowatts/HP})(100\%)}{(\text{Electrical Power, Kilowatts})}$$

8.274 Sump Pump

The lower floor of the dry well should be provided with a sump and submersible pump to collect seal water and water used to hose down and clean up the area. This drainage water should be pumped out of the dry well sump and discharged at a high elevation into the wet well.

The discharge pipe of the sump pump must include at least one check valve or, for added safety, two check valves. In addition, if the check valve is located in the vertical piping run, it should be a valve designed specifically for a vertical installation. Generally it is desirable to have the sump pump discharge into the wet well above the highest possible elevation that water could reach under flooded conditions in the wet well. This minimizes siphoning back through the piping into the dry well. Normally this is not possible but the double check valve installation provides added protection. The dry wells of many pump stations have been flooded because of check valve failure which did not prevent backflow from the wet well.

It is a good idea to install a wire mesh screen around the sump area to screen out large pieces of material which could and will clog the sump pump. In addition, installing a union on the discharge piping will facilitate easy removal of the pump for maintenance and cleaning of the sump.

8.28 Lift Station Valves

Valves are of critical importance to lift station operation and maintenance but are frequently neglected during preventive maintenance. The major valves found in wastewater lift stations are:

1. Pump suction and discharge isolation valves (gate, plug, knife),
2. Discharge check valves (swing or ball check, wafer), and
3. Cross connect or pump discharge pipe manifold isolation valves (gate, plug).

There are different types of valves used for each of the above applications and they are discussed individually in detail below.

8.280 Gate Valves

Pump suction and discharge isolation gate valves are found immediately before and after the pump to allow isolation of the pump from the wet well and the force main during pump or check valve maintenance. The most common type of valve used for this application is a gate valve in which discs or gates are used to provide a shutoff. Figures 8.32 and 8.33 illustrate a non-rising stem gate valve (NRS) and an outside screw and yoke valve (OSY).

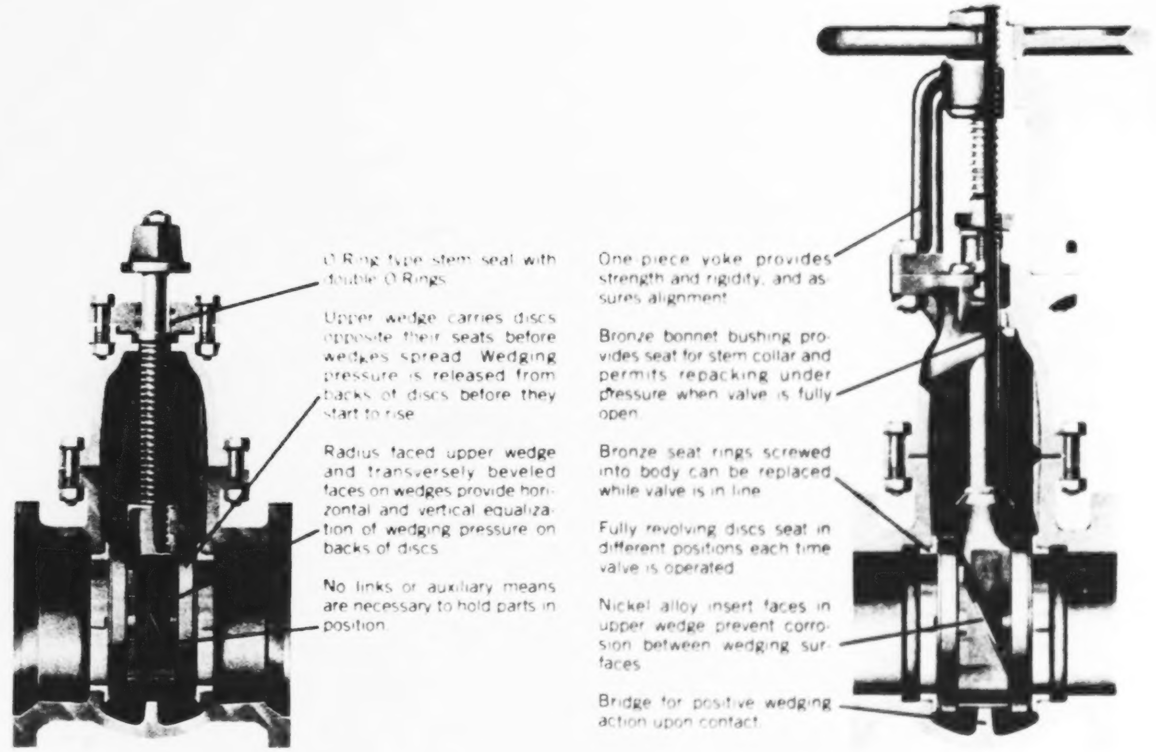
Normally, the non-rising stem valve is used in lift stations because, as the name applies, additional headroom is not required to accommodate a non-rising stem as the valve operates. The principle of operation for non-rising stem valves requires that sliding wedges, which are attached to a threaded shaft, are also attached to the discs or gates. The stationary portion of the valve has machined faces upon which the discs seat. As the wedge and disc assembly is lowered on the shaft into the flow area, the wedges slide against each other and provide wedging pressure on the back of the discs, which then seat against machined faces in the valve body.

In the open position, the wedge and disc assembly is raised into the upper bonnet portion of the valve where it is out of the flow and does not interfere with the flow through the valve. The threaded shaft normally is sealed, either through o-ring type seals or with conventional packing.

The valve should be frequently exercised, at least semiannually, in order to keep the threads on the shaft stem and the collar operational.

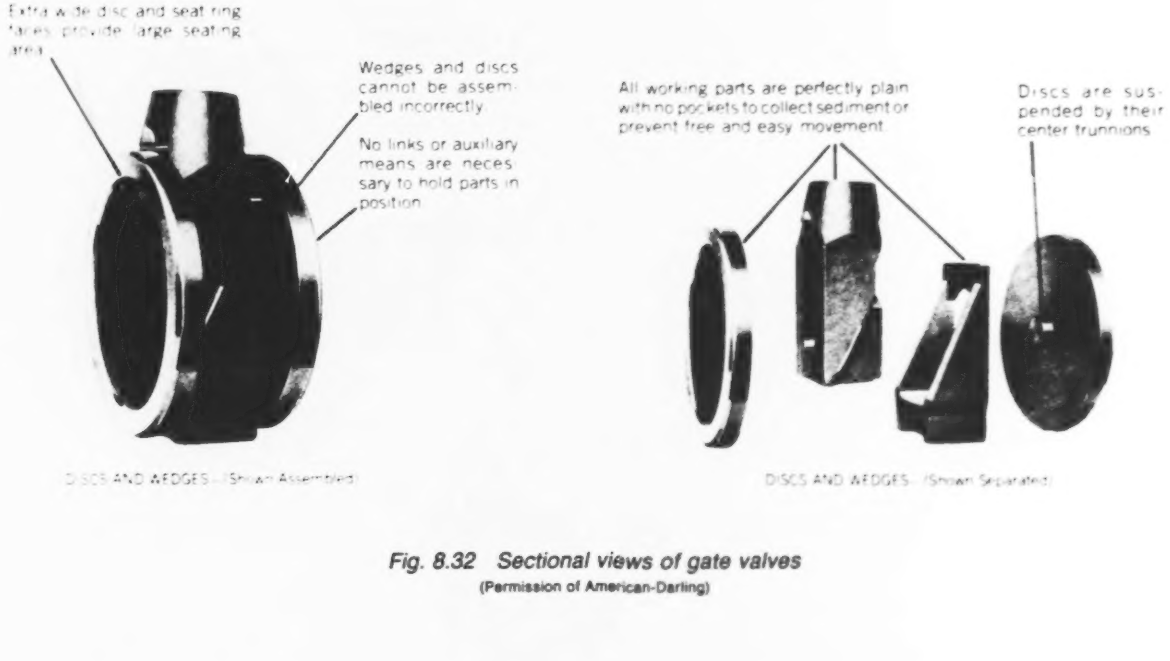
As can be seen from Figures 8.32 and 8.33, the threaded shaft, gate, and wedge and disc assembly, although it is out of the flow, can still accumulate solids in the bonnet area since the bonnet cavity is not isolated from the flow.

Solids and grease often accumulate on the shaft, thus making it difficult to operate the valve. In the event this occurs to the suction valve, disassemble the valve bonnet after isolating the valve from the wet well and the force main. This normally requires placing a pneumatic plug or bag in the suction line in the wet well. Drain the suction pipe and the pump volute of water, and then disassemble the valve. In some cases it may be feasible to attach high pressure water or an air source to the bonnet via a threaded hole with a pipe plug installed in the bonnet; however, this is not always successful.


O Ring type stem seal with double O Rings
Upper wedge carries discs opposite their seats before wedges spread. Wedging pressure is released from backs of discs before they start to rise
Radius faced upper wedge and transversely beveled faces on wedges provide horizontal and vertical equalization of wedging pressure on backs of discs
No links or auxiliary means are necessary to hold parts in position
One piece yoke provides strength and rigidity, and assures alignment
Bronze bonnet bushing provides seat for stem collar and permits repacking under pressure when valve is fully open
Bronze seat rings screwed into body can be replaced while valve is in line
Fully revolving discs seat in different positions each time valve is operated
Nickel alloy insert faces in upper wedge prevent corrosion between wedging surfaces
Bridge for positive wedging action upon contact

NON RISING STEM VALVE (NRS)

OUTSIDE SCREW AND YOKE VALVE (OS&Y)

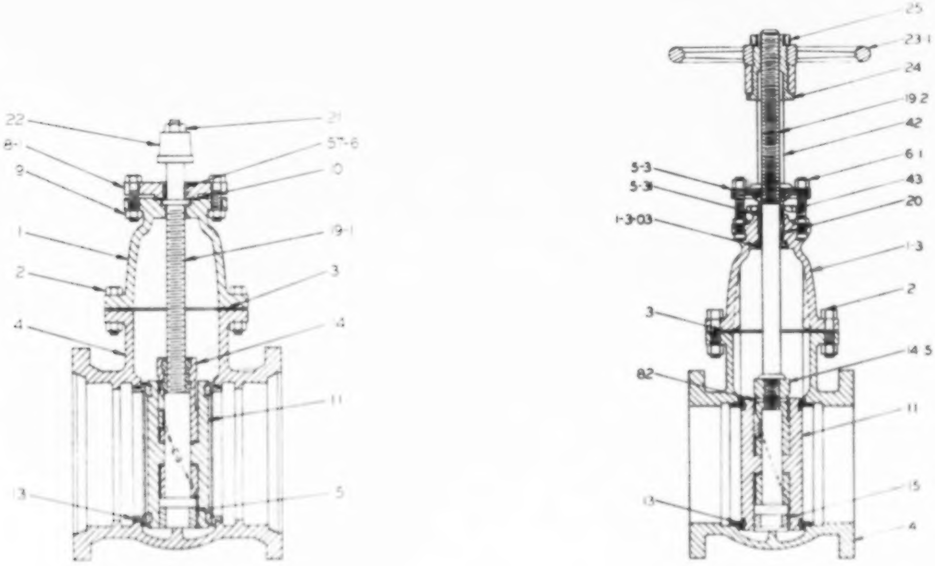

Extra wide disc and seat ring faces provide large seating area
Wedges and discs cannot be assembled incorrectly
No links or auxiliary means are necessary to hold parts in position
All working parts are perfectly plain with no pockets to collect sediment or prevent free and easy movement
Discs are suspended by their center trunnions

DISCS AND WEDGES — (Shown Assembled)

DISCS AND WEDGES — (Shown Separated)

Fig. 8.32 Sectional views of gate valves

(Permission of American-Darling)



NON-RISING STEM (NRS)

OUTSIDE SCREW AND YOKE (OS&Y)

Part No.	Name	Material	Quantity Per Valve
1	Bonnet	Cast iron (See Note 4)	1
2	Bonnet bolts and nuts	Plated steel	*
3	Bonnet gasket	Asbestos	1
4	Body	Cast iron	1
8-1	Bonnet cover	Cast iron (See Note 4)	1
9	Cover bolts and nuts	Plated steel	4
10	Cover gasket	Asbestos	1
11	Disc with ring	(See Note 3)	2
13	Seat ring	Bronze	2
14	Upper wedge	(See Note 1)	1
15	Lower wedge	(See Note 2)	1
19-1	Stem	Manganese bronze	1
21	Clamp nut	Plated steel	1
22	Wrench nut	Cast iron	1
57-6	O-Rings	BUNA-N rubber	2
23	Handwheel (Optional)	Cast iron	1

*Quantity required per valve depends on valve size.

NOTES:

1. Upper wedges on valves 2½" and smaller are ASTM B-62 bronze; 3"-12" sizes, iron with stainless steel shoes; 14" and larger sizes, iron with monel shoes. 3" and larger non-rising stem upper wedge has integrally cast ASTM B-62 bronze stem bushing.
2. Lower wedges on valves 2½" and smaller are ASTM B-62 bronze. 3" through 14", iron. 16" and larger, iron with monel shoes.

Part No.	Name	Material	Quantity Per Valve
1-3	Yoke bonnet	Cast iron	1
1-3-03	Bonnet bushing	Bronze	1
2	Bonnet bolts and nuts	Plated steel	*
3	Bonnet gasket	Asbestos	1
4	Body	Cast iron	1
5-31	Follower packing gland	Bronze	1
5-3	Follower flange	Cast iron	1
6-1	Follower bolts and nuts	Plated steel bolts bronze nuts	2
11	Discs with ring	(See Note 3)	2
13	Seat rings	Bronze	2
14-5	Yoke upper wedge	(See Note 1)	1
15	Lower wedge	(See Note 2)	1
19-2	Yoke stem	Manganese bronze	1
20	Packing	Asbestos	1
23-1	Yoke handwheel	Cast iron	1
24	Yoke stem nut	Bronze	1
25	Yoke clamp nut	Bronze	1
42	Yoke	Cast iron	1
43	Yoke bolts and nuts	Plated steel	4
82	Wedge pin	Stainless steel	1

*Quantity required per valve depends on valve size.

3. Discs on valves 3" and smaller are ASTM B-148 Alloy 954 aluminum bronze. 4" and larger, iron with ASTM B-62 bronze face.
4. Bonnet and bonnet cover of NRS valves have a bronze ASTM B-62 stem bushing on valves 16" and larger.

Fig. 8.33 Basic parts of gate valves

(Permission of American-Darling)

CAUTION! Before disassembling the bonnet, you must ensure that the pump discharge valve is shut and holding (don't depend on the check valve alone) and that the pneumatic plug or bag in the suction pipe is secure. Use an auxiliary pump to install the pneumatic bag or plug in the suction line. It may be necessary to schedule this work during the low flow periods and depending on the upstream storage and other conditions, including the availability of a tanker to pump into when using the auxiliary pump. Normally, a thorough cleaning of the valve threaded stem and the gate assembly is all that is required unless you observe severe deterioration of the faces on the discs and on the seat of the valve body. To disassemble the discharge valve, it will be necessary to drain the force main in addition to isolating it from the wet well.

The outside screw and yoke valve is similar in operation with the exception that the threaded stem actually rises and is not exposed to the accumulation of solids from the wastewater. Since the threaded portion is located outside of the bonnet, however, additional headroom is required to accommodate the rising stem when the valve is in the open position.

Under no circumstances should gate valves be buried, as is common practice in drinking water distribution systems. At some point in time a gate valve will require disassembly and maintenance. Submersible station valves should also be located out of the wet well area, since corrosion occurs and access is difficult when maintenance is required. A valve manhole adjacent to the station is a better design.

Gate valves are also commonly used in the discharge manifold and cross-connect valves in the pump station.

8.281 Plug Valves

Plug valves are another type of valve that are successfully used as suction and discharge isolation valves in lift stations and are frequently used in wastewater plants where high solids content such as sludge pumping systems are encountered.

As Figure 8.34 illustrates, a plug valve consists of the valve body and a rotating plug that operates through 90 degrees. Figure 8.35 illustrates the open, closing and closed positions of a plug valve. In the open position, the plug normally resides in the side of the valve out of the flow; in the closed position the plug seats up against the valve body providing a positive shutoff.

Many agencies specify plug valves as opposed to gate valves since they are less susceptible to plugging.

8.282 Check Valves

Normally a check valve is installed in the discharge of each pump to provide a positive shutoff from force main pressure when the pump is shut off and to prevent the force main from draining back into the wet well.

The most common type of check valve is the swing check valve which is shown in Figure 8.36. This valve consists of a valve body with a clapper arm attached to a hinge that opens when the pump comes on and closes to seat when the pump is shut off.

Check valves must close before the water column in the pipe reverses flow; otherwise, severe water hammer can occur when the clapper arm slams against the valve body seat. If this occurs, an adjustment of the outside weight or spring is usually required. A traditional clapper type of check valve has a lever on the extended shaft which allows adjustment of the weight on the arm and/or spring to vary the closing time. Wear occurs within the valve primarily on the clapper hinge and shaft assemblies and should be checked annually for looseness.

Other types of valves can also be used as check valves in larger lift stations. These valves may be air-operated or electrically operated. Plug valves are frequently used. Ball check valves are also used and rubber flapper-type check valves are used in some facilities.

8.29 Ventilation and Auxiliary Equipment

The dry well must be equipped with ventilation equipment to maintain the dry well portion of the station atmosphere in a dry and safe environment. Ventilation equipment should operate continuously to assure a safe working access for operation and maintenance operators. A lift station dry well is considered a confined space by state industrial safety agencies and requires frequent air changes. Monitor for oxygen deficiency and explosive and toxic gases during visits to the station. Wet wells also require provisions for ventilation.

In regions with high humidity, dehumidifiers may be necessary to keep condensation under control. This problem is most serious in the smaller, package-type lift stations which are of prefabricated steel. Usually the dehumidifier runs constantly, and outside air is used for ventilation only when the access cover is open. A ventilation fan can be turned on or off by a switch at the access cover. This procedure keeps moist, outside air from entering a lift station when it is unoccupied and provides the driest possible conditions.

Depending upon agency requirements or preference, lift stations also may include telemetering systems for monitoring or controlling the station operation. A flow measuring device may consist of either a Parshall flume, a weir, a magnetic meter, or a venturi meter.

The station may have emergency generator units for continued operation during electrical power failures. Large lift stations may use gas or diesel engines to operate pumping equipment due to the ease and reliability of regulating pump speed.

Some stations are equipped with individual water wells to supply seal water, water for the application of chemicals such as chlorine, or cooling systems for heat exchangers on

1. Corrosion resistant plug ■ Plug materials resist corrosion and prolong seat life. Available materials are as follows:

Bronze (½"-2" only)
Electroless nickel plated cast iron (2½"-4" valves only).

2. Double-seal for tight shutoff and safety ■ A resilient seal molded into a groove in the plug face assures dead-tight shutoff on liquids and gases without the use of sealing lubricants. When the plug is closed, the resilient seal is compressed against the seat. The metal on the plug face also makes contact with the metal seat to provide a second seal for safety. Gas industry fire tests showed that this second metal seal provides nearly bubble-tight shutoff with the resilient seal burned away.

3. O-Ring stem seal ■ A variety of stem seal materials provides maintenance-free sealing that matches valve performance and assures long life and reliability.

4. Corrosion resistant bearings ■ Permanently lubricated bearings in the upper and lower plug journals resist corrosion and assure easy operation without lubrication. And, operation is just as easy whether the valve is operated once a day or once a year.

5. Corrosion resistant seal ■ A plastic seat coating provides extra corrosion resistance to minimize plug wear.

6. Meets ANSI 125 lb. standard ■ Body walls and end connections conform to all applicable ANSI 125 pound standards. Valves meet MSS standards in ½" and ¾" sizes where ANSI standards are not available.

7. Choice of end connections ■ A complete choice of end connections includes screwed, flanged, Dresser and Victaulic. A complete listing of availability for each valve size and FIG number is shown in the ordering section.

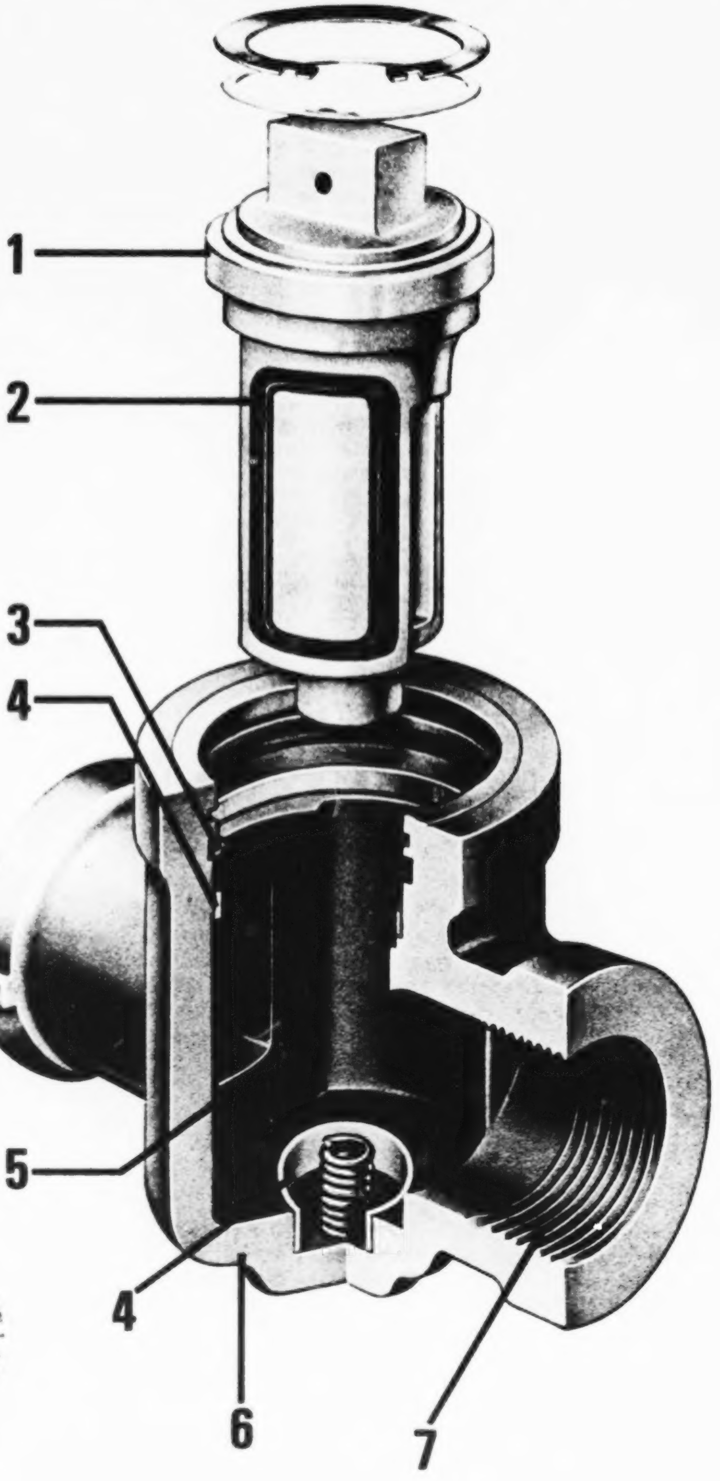
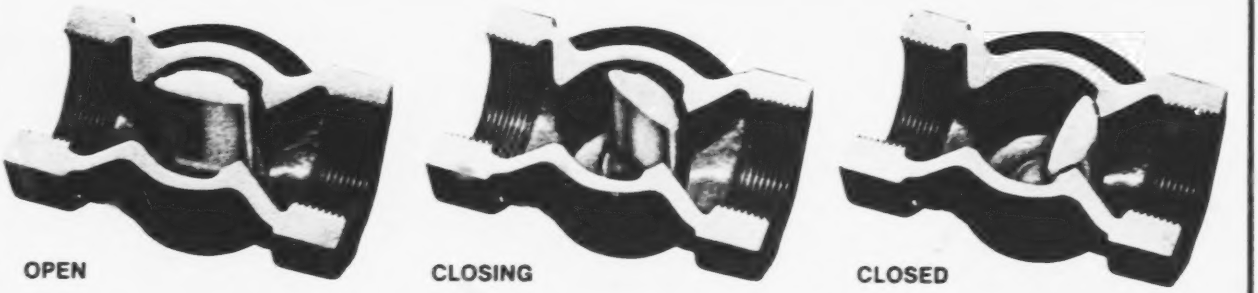


Fig. 8.34 Eccentric valve
(Permission of DeZurik)



OPEN

DeZURIK eccentric action and resilient seating assure lasting dead-tight shutoff. As the eccentric plug rotates 90 degrees from open to closed, it moves into a raised eccentric seat.

In the open position, flow is straight through and flow capacity is high.

CLOSING

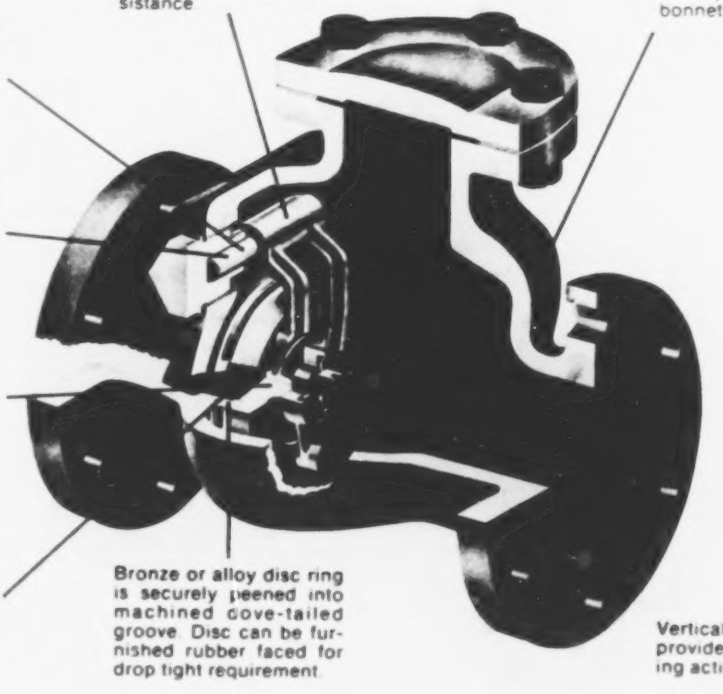
As the plug closes, it moves toward the seat without scraping the seat or body walls so there is no plug binding or wear. Flow is still straight through making the throttling characteristic of this valve ideal for manual throttling of gases and liquids.

CLOSED

In the closed position, the plug makes contact with the seat. The resilient plug seal is pressed firmly into the seat for dead-tight shutoff. Eccentric plug and seat design assure lasting shutoff because the plug continues to move into the seat until firm contact and seal is made.

Fig. 8.35 Open, closing and closed eccentric valve

(Permission of DeZurik)



Bronze bushed ductile iron clapper arm for added strength and impact resistance

Body design permits removal of clapper arm assembly with disc through bonnet opening

Tight closing assured since clapper arm shaft is set slightly back of vertical seat face

Stainless steel clapper arm shaft can be extended through body when lever with weight or spring is required

Free floating disc distributes wear uniformly over the entire seating face

Bronze seat ring is screwed in body and made with lugs and can be replaced with body in line

Bronze or alloy disc ring is securely peened into machined dove-tailed groove. Disc can be furnished rubber faced for drop tight requirement

Vertical seating surfaces provide sensitive unseating action

Fig. 8.36 Cut-away view of spring check valve

(Permission of American-Darling)

equipment. A lift station may vary from a simple and efficient telemetered design requiring a visit once a month to a highly complex installation demanding continuous staffing.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 90.

8.2Q Why should lift stations be equipped with at least two pumps?

8.2R Why must each pump be equipped with a suction and discharge isolation valve?

8.2S Why must pump seal water from a domestic water supply have an air gap?

8.2T Why do some lift stations have an emergency generator?

8.2U List the major valves found in wastewater lift stations.

8.2V Where are pump suction and discharge valves located and why?

8.2W Where are check valves installed and why?

END OF LESSON 2 OF 5 ON LIFT STATIONS

DISCUSSION AND REVIEW QUESTIONS

Chapter 8. LIFT STATIONS

(Lesson 2 of 5 Lessons)

Write the answers to these questions in your notebook before continuing. The problem numbering continues from Lesson 1.

5. What are the advantages and limitations of a wet well being too large or too small?
6. What are the advantages and limitations of having bar racks in wet wells?
7. What is the purpose of a stilling well in a wet well?
8. How is the depth of water in a wet well determined?
9. Why should isolation valves in lift stations be gate valves instead of plug valves?
10. Why must lift stations have adequate ventilation?

WHAT
WHY
WHERE
WHEN
HOW

CHAPTER 8. LIFT STATIONS

(Lesson 3 of 5 Lessons)

8.3 THE NEWLY CONSTRUCTED LIFT STATION

Many large municipal agencies do their own design work for lift stations. Smaller agencies usually rely upon a consulting engineering firm for station design. In either case, operation and maintenance operators should be given the opportunity to review the prints and specifications of a new lift station before the award of a contract for construction. This review is very important to be sure adequate provisions have been made for the station to be easily and properly operated and maintained.

When it comes to operation and maintenance of a lift station, the knowledgeable, experienced operator is an expert and can contribute to new lift station construction projects during the planning and design phase. The operator's input can have a long-term effect on the operating requirements, and therefore, the operation and maintenance budget of the station. Participation by the operator during planning and design will result in the following positive contributions:

1. Identify problems in existing stations to ensure that those problems are eliminated in new stations,
2. Make the station more reliable, reducing the number of emergency call outs,
3. Increase operator safety,
4. Provide for sufficient space to safely operate and maintain the facility, and
5. Reduce maintenance required, including emergency maintenance (EM), corrective maintenance (CM), and preventive maintenance (PM).

Keep in mind that it is not the operator's job to tell the engineer how to design a facility, but rather to provide positive input on improving the operation and maintenance of the station. If possible, be very specific and make recommendations. A carefully kept log of existing station operation maintenance requirements will assist the engineer. The operator should have an opportunity to participate in the project design in the following stages:

1. Planning stage,
2. 20% design review,
3. 40% design review, and
4. 90% design review.

8.31 Examination of Prints

When examining the prints, operation and maintenance operators should look for accessibility not only for equipment, but for operators to get to the station. Is there sufficient space for vehicles to park and not restrict vehicles passing on streets or pedestrians on sidewalks? Is there room to use hydrolifts, cranes and high velocity cleaners as needed at the lift station? Are overhead clearances of power lines, trees and roofs adequate for a crane to remove the largest piece of equipment? Are lifting hooks or overhead rails available where needed in the structure? Has sufficient overhead and work room been provided around equipment and control panels to work safely? Is lighting inside and outside the station provided and is it adequate? Does the alarm system signal high water levels in the wet well and water on the floor of the dry well? Is there sufficient fresh water at a high enough pressure to adequately wash down the wet well? Are there any operator traps or head knockers such as low-hanging projections or pipes, unprotected holes, or unsafe stairs or platforms? What happens when the power goes off and backup or standby systems fail? Is there access to the wet well? If you have to clean out incoming lines, it may be necessary to put a temporary pump in the wet well. All of these questions must be answered satisfactorily if the lift station is to be easily operated and maintained.

Equipment should be laid out orderly with sufficient work room and access to valves and other station equipment, controls, wiring, pipes and valves. If there is any possibility of future growth and the station may be enlarged, be sure provisions are made to allow for pumping units to be changed or for the installation of additional pumping units. If additional pumping units will be necessary, be sure spools and valves are built now for ease of expansion. Be sure there is sufficient room to add electrical switchgear for future units. If stationary standby power units are not provided, make certain there are external connections and transfer switches for a portable generator.

8.32 Reading Specifications

Review the specifications for the acceptability of the equipment, piping, electrical system, instrumentation, and auxiliary equipment. Determine if the equipment is familiar to your agency and if its reliability has been proven. Find out what warranties, guarantees, and operation and maintenance aids will be provided with the equipment and the lift station. Require a list of names, addresses and phone numbers of persons to contact in case help is needed regarding supplies or equipment during start-up and shake-down runs. Services of factory representatives should be available during the intitial startup of all major pieces of equipment. Require factory representatives to demonstrate the operation of equipment under all possible operating conditions. Be sure that the equipment brochures and other information apply to the equipment supplied. Sometimes new models are installed and you are provided with old brochures.

Be sure the painting, color coding on pipes and electrical circuits meet with your agency's practice. Try to standardize electrical equipment and components as much as possible so one manufacturer can't blame the other when problems develop. Standardization also can help to reduce the inventory of spare parts necessary for replacement. A few hours spent reviewing plans and specifications will save many days of hard and discouraging labor in the field in the future when it is a major job to make a change. Very often changes on paper are relatively simple.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 90.

8.3A Why should operation and maintenance operators be given an opportunity to review the prints and specifications of a new lift station before the award of a construction contract?

8.3B Why is accessibility to a lift station important?

8.3C What information should be determined for equipment to be installed in a lift station?

8.3D Why should prints and specifications be carefully reviewed?

8.33 Preliminary Inspection of a New Lift Station

After a lift station has been constructed it is inspected by the contractor, the engineer, and the operating agency before final acceptance. This inspection should be planned and conducted by the people responsible for the operation and maintenance of the lift station in cooperation with the contractor and the engineer.

One way to accomplish this is to include in the specifications a specific schedule that identifies the section of specification, the item to be checked and who is responsible; for example, electrical contractor, mechanical contractor, or other specific contractor. Then check off each item by noting who accepted each item and the date. All equipment checkout and adjustments should be performed *PRIOR* to any equipment training as this will maximize the amount of time spent on training as opposed to adjustment and troubleshooting.

Documentation is particularly important for proper operation and maintenance of the lift station equipment. The equipment manufacturers' O & M manuals should include the following:

1. A suitable binder that allows for quick and easy reference to all mechanical/electrical and hydraulic equipment provided in the pump station. Generally, xerox copies should not be accepted, since they may be illegible, and therefore, of limited value to the operator.

2. Information about each piece of electrical and mechanical equipment should include nameplate data, operation and maintenance instructions, spare parts list, recommended spare parts stock list, part numbers, troubleshooting information, assembly/disassembly instructions, tolerances, tools required, and safety precautions. In other words, a sufficient amount of information to allow adequate maintenance of the equipment.

3. The manual should be available when you accept the station from the contractor, not three months later.

Now, during the preliminary inspection, is the appropriate time to develop and record both routine and emergency information and procedures. Use the following outline as a guide in assembling your documentation.

1. As-built specification of the facility including:
    a. Size, length and details of force main (discharge point)
    b. Available power and fuse size
    c. Pump and motor sizes and rated capacities
    d. Actual capacities of pumps and rates of flow throughout the day
    e. Normal pump levels-start/stop/high and low levels
2. Elevation of each manhole invert and depth of the manhole
3. Lowest homes on the system (most probable backup points)
4. Alternate route of temporary pumping:
    a. Elevation and length of temporary pumping
    b. Type of equipment needed
5. Number of services, plus commercial hookups
6. Available equipment and methods of operating station when a power outage occurs
7. Equipment needed for pump and motor removal
8. List of private companies providing emergency pumping equipment and personnel
9. Station data:
    a. Wet well size
    b. Storage time, average flow
    c. Average flow, GPM
    d. Peak flow, GPM
    e. Average flow, GPD
    f. Wet well depth
    g. Distance of bubbler tube off wet well bottom
    h. Type of wet well suction

8.34 Pump Station Calibration

As part of the startup and acceptance procedure, a pump station calibration should be performed to:

1. Verify operating conditions of the pumps in accordance with the nameplate, and

2. Establish a base line that can be used for comparison when future pump station calibrations are performed.

   The calibration of pump station is a fairly quick and easy method to verify the operating efficiency of the pumps including capacities and discharge heads.

Operation under test conditions will reveal only the immediate equipment and construction problems. These problems should be recorded on a punch list during the preliminary inspections and a copy given to the contractor. This punch list of problems should be quickly corrected so the station can be ready for service. Do not accept any portion of a new lift station, because official acceptance of completed work is the engineer's job.

To obtain maximum life and use from a new lift station, begin the station preventive maintenance program now when it is new. Start the program by filing data in a station record book. Record station identification code number, location by map and street numbers, date of construction, size of station by flow capacity and other important information required by your agency. Also file a set of plans and specifications for reference purposes.

Start the preventive maintenance program by making a complete list of all equipment at the station. See Chapter 9, Section 9.28, Records, for typical data sheets. Information recorded should include equipment name plate data. Mark each piece of equipment with an identification code number and record the number. There should be a minimum of two copies of this information. Keep one copy at the lift station and the other in the station record book at the agency office. Once this has been done, permanent identification of all equipment involved in the station will be available when needed. Prepare a spare parts list and order any extra parts now.

Recordkeeping must begin when the station is first started so that any peculiarities of the equipment are known from the beginning. These records should include any of the contractor's data collected during construction and also data required according to the specifications. These specifications include:

1. Equipment manfacturers' O & M manuals,
2. Engineers O & M instructions, including detailed emergency procedures,
3. Pump and motor operational characteristics,
4. Pump and motor coupling alignment readings,
5. Wet well control levels, and
6. Auxiliary equipment data.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 90.

8.3E Who should inspect a lift station after it is completed, but before it is accepted?

8.3F Where should information regarding lift station equipment and performance be filed?

8.3G Why should data from initial tests on equipment be recorded and filed?

8.35 Inspection of Lift Station

Hopefully you had the opportunity to review the plans and specifications for the new lift station. Now is the time to determine if the station was built as you wished. Look at those items you previously reviewed. Ask yourself what problems will be faced when maintenance and repairs are to be carried out under adverse conditions. Think of the worst situations so that your preparations will be adequate when needed.

Inspect the building for access so equipment can be removed. To insure that equipment can be worked on, the following items must be considered. Is there an emergency lighting system and is it adequate? Is there enough head room to pull pumps, motors, gear heads or other pieces of equipment? If head room is not needed, are the passageways wide enough to allow for the removal of gear boxes, engines, control panels, and standby generators? If pumps have to be removed through the roof of a building, do we have clearance for a crane or other lifting device to get within reaching distance? Where are the electrical lines located that supply the building? Will they restrict use of the lifting equipment? The time to consider all of the above is now, not when conditions are adverse. If there are potential problems related to equipment removal, the time to correct these problems is now. Plan to conduct corrective work before a crisis occurs. Don't wait for an emergency to arise to discover that a critical piece of equipment can't be moved when a unit needs repair. Dismantling equipment in place under restrictive conditions is slow and difficult work.

The next unit to inspect is the wet well. What kind of conditions will be encountered when you attempt to clean the sump or possibly to enter it and remove grit? In a sanitary wet well, are there enough openings for washing the sump walls and floor? Can it be ventilated easily? What type and size of ladder will you need for access? If there is a bar rack, or comminuting device, consider the conditions you will encounter to clean the rack and how you will dispose of the debris. Also consider the tools needed and whether or not the necessary tools will be stored at the site. If tools must be transported, make notes of what will be needed and how transportation will be accomplished. Inspect the equipment that measures the water level in the wet well.

Before entering any lift station or other wastewater facility, safety procedures must be followed to insure that the hazards encountered will be eliminated or brought to a minimum. The hazards are as follows:

1. Insufficient oxygen,
2. Explosive and toxic gases,
3. Poor footing caused by grease or slimes,
4. Unsafe stairs and walkways,
5. Dangerous electrical gear, and
6. Inadequate drainage.

If the wet well is to be entered, begin by setting up a blower that will give a minimum of two air changes a minute within the wet well. The wet well must be washed thoroughly using a hose with a nozzle. After washing has been completed, the wet well can be monitored for toxic or poisonous gases, explosive gases, and lack of oxygen. *IF ALL CONDITIONS ARE SATISFACTORY, THEN AND ONLY THEN IS IT PERMISSIBLE TO ENTER THE WET WELL.* All of the safety equipment and clothing listed under safety for confined spaces should be available for use at this time (see Chapter 10, Section 10.5, Manholes and Other Confined Spaces). Monitor the wet well gases and oxygen continuously until the job is completed and everyone is out of the sump.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 90.

8.3H What problems may be encountered when cleaning a wet well?

8.3I What are the hazards found in confined spaces that handle wastewater?

8.3J What can you do to eliminate or reduce to a minimum the hazards encountered in sumps?

The next item to inspect is the electrical equipment. Begin by recording all name plate data. Put code numbers on each panel beginning at the main breaker. Branch panels that supply power to major circuits carry the code number of the piece of equipment that it serves. A lighting branch panel has its own listing or numbers and the lights or plugs it serves also carry this number. With a system like this, the problem of locating controls, plugs, and lights is quite simple.

Individual inspection of the major circuits is necessary. Record the parts that most likely will need attention during an emergency. All fuses must be listed and spares kept at the station. Data on switches, relays and heater strips must be recorded. Be sure that all overload heaters are the proper size. Control circuit equipment must be listed. Identify all related equipment with proper code number.

Make this inspection with the main breaker to the equipment being inspected locked in the *OFF* position. No attempt should be made to inspect or repair electrical equipment unless a basic knowledge of electricity and the safety precautions needed are fully understood and applied. Request an electrician to help if you are not qualified or not authorized to inspect electrical equipment, circuits and controls.

After listing all necessary data and putting code numbers in place, read the operating instructions and examine the controls for their proper operation. Move all switches with the power off to see how they operate. Check reset buttons and know what they are supposed to do. Before the station becomes operational, it is essential to learn how things are supposed to work.

The approach to solving any problem must be made with logic and caution. Be deliberate and think each step out before making any changes. Mark all settings, if possible, so that you can return to the starting point. Wait a short period when changing settings to obtain and observe the results. Do not make a change if you think it is not safe.

Before leaving the electrical equipment, tag any dangerous area with "not to be tampered with or touched by inexperienced hands" and lock out.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 90.

8.3K Where should the inspection of the electrical equipment begin?

8.3L When inspecting an electrical circuit or equipment, in what position should the main breaker be positioned?

8.3M Should there be extra fuses kept at the station? Why?

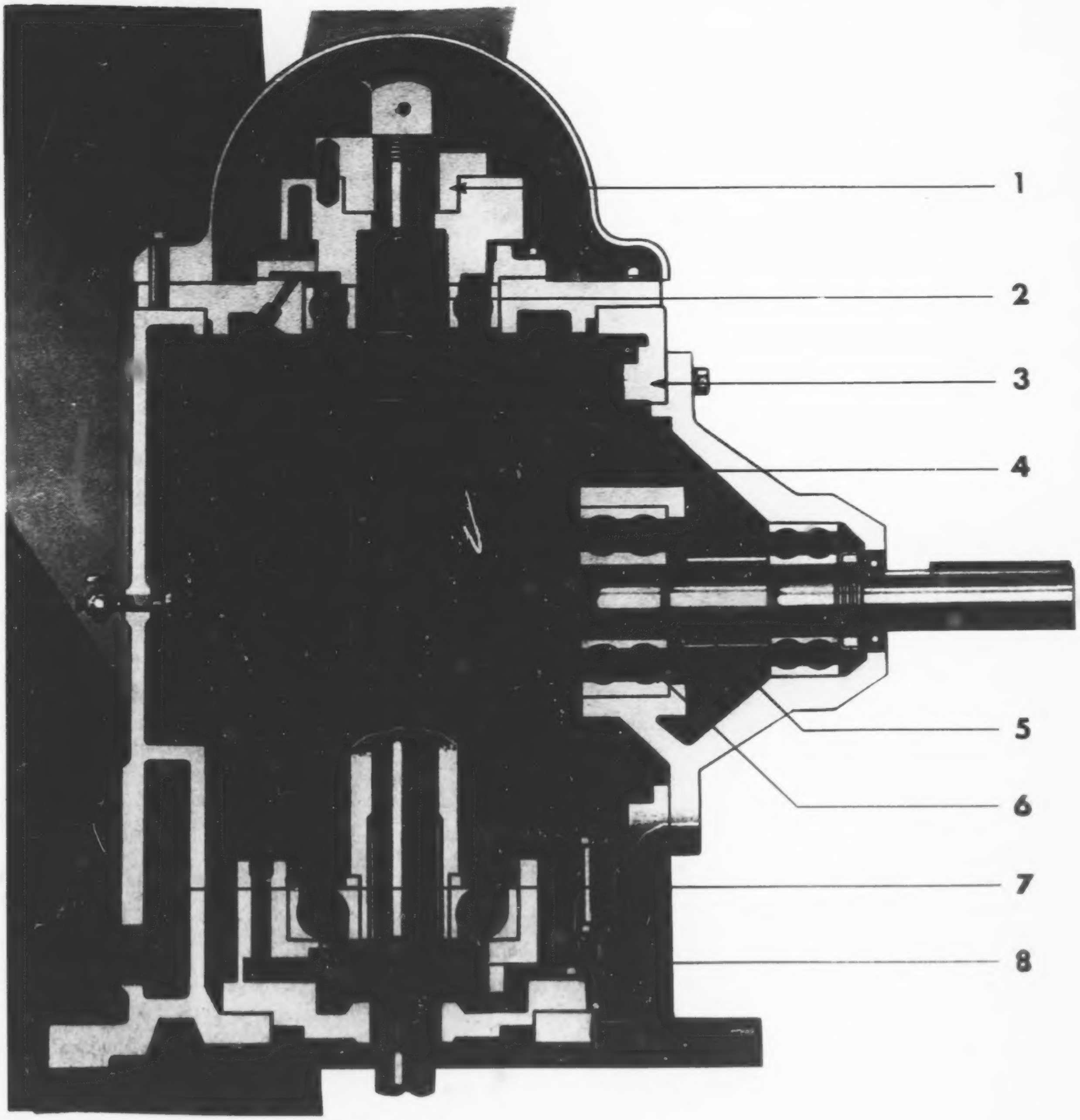
8.3N When should you learn how the electrical circuits work?

The next point of inspection is the pumps. All name plate data must be recorded. Lock out pump and determine direction of rotation. If local electrical utility company has worked on their lines near the station, be sure the power leads (legs) are hooked up correctly and the rotation of the pumps is in the proper direction. Inspect the backspin preventer if the pumps are so equipped by trying to turn the pump shaft in the direction against the indicated rotation. Backspin equipment operation also may be detected by listening to the pump motor when the unit is shut down after a run. When the unit comes to a stop, the backspin unit begins to engage and it can be heard as a ratcheting sound. If a right-angle gear head is used, the backspin equipment may be located on this unit. Equipment specifications will have to be checked to determine if there is anti-rotation equipment provided in the gear head. Examine all gages for location and determine at this time what they are to indicate. Any valves located on the suction or discharge should be opened and closed to examine for correct and easy operation so that you are familiar with them. Place equipment numbers on these valves so that a preventive maintenance card can be made to service them. Maintenance record cards should be prepared for each piece of equipment inspected. Inspect the drive and pump for proper alignment. If belt-driven, record the sizes of the belts and numbers so that spares will be available when needed. Inspect all rotating parts for missing guards and secureness. The guards must be built for easy access to the equipment being shielded, but still meet all safety requirements.

Inspect the lubrication equipment used and note all pertinent information needed to keep it operating. Solenoids used to operate the oilers should be standardized when reviewing the specifications in order to reduce the inventory of spares necessary for replacement.

Inspect suction and discharge lines. The suction line must be kept clear of debris. If a check valve is supplied on the pump discharge pipe, this valve can become a problem when stringy material gets caught on the flapper and it stays in the open position.

If the lift station uses gasoline or diesel engines, they may be in the form of stand-by generators or as a pump drive. When used as a pump drive, the operation may go through a right-angle gear unit (Figure 8.37). These units are used to keep a large engine from being located on a lower deck where the pump must be located for efficient operation. The engine is kept on the top for easy access, cooling, ventilation, exhaust, and above the level of flooding.



1. Clutch
2. Vertical output shaft assembly
3. Housing
4. Gear and pinion
5. Horizontal input shaft assembly
6. Anti-friction bearings
7. Cooling
8. Lubrication

Fig. 8.37 Right-angle gear drive

(Courtesy of Fairbanks-Morse)

87

There will be very few problems with the right-angle gear if the proper design unit is used for a given job. The most important point is to have the proper lubrication for the gears. Preventive maintenance will maintain the unit free of leaks. Cooling is supplied to some units, but only when the gear head is to run continuously for a long period of time. You must inspect the drive shaft and its universal joints. Lubrication is necessary, but should be kept to a minimum because too much will rupture the seal on the universal and cause failure by allowing the entrance of foreign material.

The engine must be inspected for sufficient oil, water and fuel to operate properly. Without any of these, the unit will not function properly. Examine the battery for water, tight cables and clean terminals. If the engine is large and requires compressed air for starting, inspect the auxiliary air system. Inspect and adjust alarm system for proper operation at the predetermined points of alarm or shut-down. Failure of the alarm system to shut-down devices could cause an engine to burn up. Make sure that all hoses are secure and clamped tight. Loose nuts and bolts must be tightened. Be aware of the ones that continually become loose. A different type of fastener may solve this problem.

Leakage of any sort should not be tolerated. Keep cleaning equipment at the station to keep leaks wiped up so that you know when a new leak starts. Vibration will continually cause problems of leakage and loose parts, so you must never let up on your preventive maintenance program.

If there is a clutch to disengage the engine from the drive shaft, test its operation. It should be a little hard to engage and disengage because the unit must snap over center when operated.

Lubrication of the clutch throw-out bearing should not be excessive because the friction plates will fail if contaminated with grease. The engine should be maintained as you maintain your automobile engine. Change the oil on a regular schedule to remove contamination from the engine's inner parts. Inspect the oil for metal filings and sludge when changing the oil to stay aware of the engine condition. If filings are noted, a failure of bearings may be assumed. Look for water or an oil-water emulsion that indicates water in the wrong place. If a qualified lab is available, oil may be tested to determine when a change is necessary.

Sludge indicates that excessive dirt or carbon have found their way into the crankcase. This may be a failure of the engine's breathing system or just plain blow-by at the rings. Engines should be run from two to four hours during extensive test runs to permit complete heating of all parts and to observe performance during continuous operation. Inspect the engines' heating and cooling systems. Short runs of 5 to 15 minutes should be avoided (especially with large engines) because this is when the most damage can be done to a cold or not properly heated engine. If the engines are not being used, they should be test run carrying a typical load for one hour every two weeks.

Determine what type of fuel is to be used and the storage capacity, the engine's consumption rate, and when the fuel will be delivered. The fuel tank should be kept full so condensation won't collect on top of the tank.

Inspect all controls for free and easy operation. Make a record of their settings before and after operation. This becomes the standard and a starting point for troubleshooting when problems occur in the future. When operating, set marks can be made with fingernail polish at the set point. The question may arise at this point as to why bother to check everything on the engine so thoroughly? Inspecting and obtaining a standard for the engine will help tremendously when problems do occur. The jobs of troubleshooting and repairing become easy when there are good data for reference. This data can be obtained only when the engine is new or rebuilt and is being operated for the first time.

The final point of inspection is the housekeeping needed to maintain an acceptable station which will satisfy the public or surrounding area. Inspect all fences to see that they are complete and have a neat appearance. If made of wood, be sure the paint has good color and is protecting the wood. Chain link fences usually require little maintenance, but should still be inspected for damage or poor installation. Metal chain link fences must be grounded in case a power line drops across them and an unsuspecting operator goes to open the gate. Examine all paved areas for proper drainage and good workmanship when an area is paved. Inspect unpaved areas for weed control.

Examine all exterior parts of buildings. Look for poor installation or possible future problem areas. At this time, get a ladder and inspect the building's roof. Be sure that all openings are adequately covered or louvered.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 90.

8.3O What is the purpose of anti-rotation equipment on a pump?

8.3P What can happen if a universal joint is over-lubricated?

8.3Q What can happen to an engine if its internal alarm system fails?

8.3R What must one look for when changing engine oil?

8.3S Why is the engine examined so thoroughly?

8.3T What precautions should you take when lubricating the clutch throw-out bearing?

8.3U When is condensation likely to form inside an engine?

8.3V What three items must we have for engine operation?

8.36 Operational Inspection

We are now ready to operate the lift station. Open any valves on the influent line to fill the wet well. Make certain that the pump volute drain lines and vent lines are closed. If there is no wet well, open the valve to the suction side of the pump. Inspect the sump and bar rack at this point for debris and free flow into the station. Remove the floating debris left by the contractor in the sump or off the bar rack that you should have removed *BEFORE* the station was placed in service. Problem materials include small pieces of wood, like grade stakes or pieces of plastic of any size, cans, and bottles. Some objects can plug off the eye of the impeller.

With the sump filling, inspect your sump level indicator to see that it is working properly. If there is no indicator, visually check the sump level or watch the rise in the pump control stilling well. If a bubbler system is used, watch the pressure gage indicator and verify wet well level readings with actual readings. Once the station is in operation, the determination of the sump level will become a part of the normal inspection for system maintenance.

Inspect the discharge side of the pump for clear passage of the liquid to be pumped. All valves must be open. Bleed air from volute of pump. Sumps usually fill slowly unless a means of causing rapid filling can be found, such as using water from a fire hydrant.

When the sump is filling, recheck for power to pump and proper rotation of the pump. If an engine is the power source, it must be checked out before operating. Put the pump on manual operation and momentarily start pump. Watch rotation of pump shaft to see that rotation is correct. There is usually an arrow attached to the side of the pump to indicate the proper direction. If there is not, you will have to refer to the manufacturer's manual to find out how to determine correct rotation. If the pump is a centrifugal pump, the rotation is in the direction of the volute. Another means of determining rotation is to take a load check of the amperage drawn by the pump motor and compare this value with motor name plate data. If the rotation is in the wrong direction, the amp reading will be lower than the motor rating due to less work being done by the pump by rotating backwards. If the discharge flow is low or the wet well is being drawn down slowly, the rotation could be in the wrong direction. Higher amp readings can result from head conditions lower than design head conditions. Low head conditions can be corrected temporarily by throttling a discharge valve or permanently by installing an orifice plate in the discharge piping.

Now that the rotation is in the proper direction, the next job is to see that all operating controls are put into the automatic position for the test operation. Start by examining all automatic switches to see that they have been put into the automatic position. Circuit breakers must be checked to see that they are in the on position. Oilers or solenoids operating the oilers should have been inspected during previous inspections. The electrical alarm systems must be examined to see that they are in the activated position. The electrical components of an engine must be inspected to be sure that there are no drains on the battery. The mechanical inspections should include inspecting all valves to see that they are open or closed according to the operation desired. You must be sure that all oilers have been filled and are not dripping. If a bubbler system is used, an inspection should be made to determine that it is functioning properly and that there is enough air pressure provided to make the control system operate.

Other mechanical checks should be made on the engine. Determine that the linkage is ready to operate. Inspect the clutch to be sure that it is engaged. Examine all cooling water valves to see that they are in the proper position.

Check to see that preheaters (if provided) on the engine are operating. The heaters inside the building should be examined to see that they are functioning to maintain the proper humidity and temperature within the station. Up to this point we have been recording all the data that have been observed. This information becomes your base for future operation reference.

Notify operators of downstream lift stations and wastewater treatment plants that the lift station is being tested and tell them the volumes of water that can be expected. Allow the sump to fill and activate the station. Watch the level of water in the sump to be sure that the pump starts at the desired level. If not, adjust this operating point by whatever means are available.

The pump must be stopped after being started so as not to pull the sump level down too far. When the starting point has been set by a visual or simulated means, we can continue to the next point of operation and that is to allow the sump to continue to rise. If more than one pump is involved, each start position for each pump must be determined and recorded as the level rises until all start points have been activated. Allow the level to rise and activate the high level alarm.

At this point you may now start the pumps in their reverse order. Each pump when started must be inspected for its operation and all data recorded. The first item to inspect is the electrical load on motors. Record any electrical malfunctions and have them corrected. The pump should be inspected for proper operation and any unusual noises or vibrations noted along with excessive heating.

Inspect the packing gland or mechanical seal. If the unit has a mechanical seal, there should be no leakage. If it is a packing gland, get the data on size of packing needed. Set packing so that there will be leakage of approximately one drop per second. If the packing is Teflon, you must adjust the gland tight with your fingers and run the pump 15 to 30 minutes while you watch the packing gland. Teflon will expand. Do not tighten gland during this period of operation. You are watching to see that it does not get hot. If Teflon gets hot it will glaze and stop working properly. After this period of operation, adjust the packing gland nut one *FLAT*[9] tight by turning bolt one flat on nut. Maintain one to three drops of water per second on the packed glands. No more adjustments are necessary. If leakage continues excessively, something wrong was done when the unit was packed and it must be repacked.

Most packed seals have flushing water supplied to the seal. The pressure needed here is 3 to 5 psi above the pump discharge pressure. There should be a filter in the flushing line if the water being pumped is used for this flushing water. Obtain all the information needed to service the unit and to have spare parts available.

Do not operate any unit if you think it is not functioning properly. Shut it down and have the contractor examine the problem. When the problem is corrected to your satisfaction, you may proceed with the test operation. All gages should be inspected and their set points recorded. Continue with the individual operation of all pumps until they have been checked out to your satisfaction. They must comply with the specifications and operate on the performance curves as intended by the design engineer.

When all data have been recorded, shut the pumps off and allow the wet well to refill. When full again, operate the pumps to adjust the shut-down points. You may have to operate more than one pump to pull the sump level down. While pumping the level down, observe the pumps in operation and record any unusual conditions. With all set points adjusted, operate the station on automatic a number of times through the full range, observing what happens and recording the results. Too much information is better than not enough. When you are satisfied that the automatic system is operating in a consistent manner, notify the engineer that the lift station is acceptable to you and you wish to put it on line.

During the first few weeks of operation, frequently inspect the equipment. Bearing failures and other problems may develop after a few days of operation.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 91.

8.3W How much leakage should there be from a packing gland?

8.3X Are there any special precautions with Teflon packing?

8.3Y What minimum pressure is needed for the flushing water on a mechanical seal?

8.3Z What would be the first thing that you should do before operating the station?

8.3AA Why should you bother to remove the debris left in the sump?

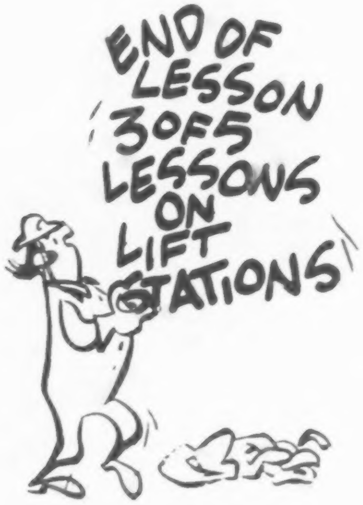
8.3AB What are the ways or means used to determine whether the sump level is rising or not?

8.3AC How do you inspect pump rotation?

8.3AD Is it necessary to inspect all points of operation if there is more than one pump located within a station?

8.3AE Should you continue operating a unit if you feel it is not functioning to your satisfaction?

8.3AF Why is it necessary to record all data when test operating the station?


END OF LESSON 3 OF 5 LESSONS ON LIFT STATIONS

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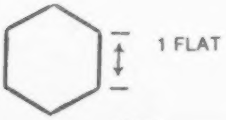
[9] *Flat. A flat is the length of one side of a nut.*



DISCUSSION AND REVIEW QUESTIONS

Chapter 8. LIFT STATIONS

(Lesson 3 of 5 Lessons)

Write the answers to these questions in your notebook before continuing. The problem numbering continues from Lesson 2.

11. How would you examine or review a set of prints and specifications for a new lift station? or What items would you be sure were satisfactory from the viewpoint of operation and maintenance operators?
12. Who should inspect a newly completed lift station? and What items should be inspected?
13. When should a preventive maintenance program be started for a new lift station?
14. What items would you inspect in a new engine in a lift station?
15. How would you make an operational inspection of a new lift station?
16. What would you do if an operating unit is not functioning properly?

CHAPTER 8. LIFT STATIONS

(Lesson 4 of 5 Lessons)

8.4 OPERATION OF WASTEWATER LIFT STATIONS

After a lift station has been constructed and put into operation, it is the responsibility of the operating agency to insure the continuous and efficient operation and maintenance of the lift station, including the structures and the grounds. This responsibility includes preventing failures in operation that would result in flooding upstream homes, businesses or streets. Responsible design includes no facilities for bypassing wastewater to rivers, streams, lakes or drainage courses. When emergencies occur, portable emergency equipment must be used to pump the wastewater to a functioning section of the downstream collection system and not to the environment. When untreated wastewater is discharged to the environment, public health hazards and pollution of adjacent receiving waters result.

Lift stations may be located throughout a community and must be neat in appearance, blend with the architecture and landscaping of the neighborhood, and not create a nuisance to neighbors through odors or noise. Complaints from the public will be few if the operators responsible for the lift station maintain the facility in top operating condition and respond to questions or complaints from the public in a positive and concerned manner. When responding to a complaint, be sure to tell the public what has been done or will be done to correct the complaint.

8.41 Lift Station Visits by Operators

ONE RULE THAT SHOULD APPLY TO ALL LIFT STATION VISITS IS THAT FOR SAFETY PRECAUTIONS, THERE MUST ALWAYS BE TWO OPERATORS MAKING THE STATION VISIT. Many state OSHA agencies consider a wastewater lift station a confined space. Safety precautions regarding the potential presence of hazardous gases apply not only in the wet well, but in the dry well area of the station too. This rule must be obeyed during off-duty hours such as nights, weekends and holidays when operators are responding to lift station telemetry alarms. Always take the few extra minutes to pick up the required additional crew member. The additional effort is critical and worthwhile when compared to the sorrow and costs that result from an injury or a lost life.

The two-operator crew usually consists of:

1 Maintenance Mechanic I, and

1 Maintenance Mechanic Helper.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 91.

8.4A How can nearby streams and rivers be protected from wastewater when a lift station fails?

8.4B How can complaints from the public about a lift station be minimized?

8.4C What is the most important rule that always must be considered when visiting a lift station?

8.42 Frequency of Visits to Lift Stations

A rule cannot be developed for determining the frequency of visits to lift stations for operational inspections. The frequency of lift station visits varies by community and may range from continuously staffed pumping plants, twice daily visits, once a day, two to four times a week, once a week, to once a month visits.

Frequency of lift station visits depends on the following:

1. Number of stations in the community,
2. Type of wastewater being conveyed,
3. Potential damage resulting from storms flooding station,
4. Condition of equipment, such as equipment temporarily repaired and waiting for replacement parts,
5. Design of facility and equipment installed in the lift station,
6. Adequacy of preventive maintenance and overhaul program,
7. Type, adequacy, and reliability of telemetry system, and
8. Attitude of operating agency towards operation and maintenance.

The attitude of the operating agency is probably the most significant factor today in determining the frequency of lift station visits. Many operating agencies make daily visits to their stations because they have always visited lift stations daily and also because they know that a great number of other communities make daily visits. However, have the people responsible for station operation and maintenance analyzed their collection system and their operation and maintenance programs and proved that daily station visits are required? To conduct this type of analysis, records must be kept and studied in order to answer the following questions:

1. How many station failures are found each day?
    a. Electrical power failures.
    b. Failure of level-sensing or other control equipment.
    c. Flooded wet wells.
    d. Plugged pump impellers or lines.
    e. Overheated and tripped-out motor thermals.
    f. Sump pump off and sumps or dry wells flooded.
    g. Air- or gas-bound pump.
    h. Stuck or blocked check valve.
    i. Pump control systems not functioning.
    j. Failure of lift station telemetry system.
    k. Ventilation fans burned out.

2. What functions were performed at each lift station that kept the station operating, and what would have occurred if the function had not been performed during the daily station visit?

    For example, assume a pump impeller was plugged with rags and not pumping. The station crew during their visit and inspection discover the problem, derag the pump and restore the pump to service. However, if the pump had plugged immediately following their visit, the telemetry system would have indicated a failure. This crew or another crew would be dispatched to return to the station. If the pump was not telemetered, the back up or alternate pump would have pumped the wastewater until a high wet well level was reached. At this point a high water level alarm would have been activated or the other pump would have handled the flow until the next day when the crew again routinely visited the station. Therefore, with an adequate telemetry system, a routine visit is not essential under these conditions.

3. How many actual hours of work are performed at each station during the visit? Do not include crew travel time to the station.
4. What is the critical period of time if the station does fail?

    This time period is the length of time from when the failure occurs at high water level in the wet well to when back-up flooding or overflow will occur. When this critical time is determined (it should be reevaluated annually because flow conditions change), it provides the time available for a station crew to respond to an alarm condition. Any critical time under one hour creates a serious problem for the operating agency and corrections should be made by installation of larger pumps. If power failures are a problem, an emergency generator should be installed to operate the station during power failures. Another possibility is to staff the station on a continuous basis and to operate with manual controls or overrides during power failures.

Lift stations operate automatically and, if properly designed and maintained, do not require daily visits under most circumstances. Typically the daily visit is usually a quick inspection of the power panel for tripped breakers, indicating lights of operating equipment, flow data and recording elapsed time meter readings. Motors in the station are usually examined to see if they are noisy or running hot. Items typically checked during a visit include the pump packing or seal system, check valves, and suction and discharge pressures, routine lubrication and clean up. The sump pump switch is flipped to see if it is operating. The visiting crew may bleed condensate from the air bubbler system for wet well and pump control and glance at the wet well indicator to see if it is reading properly. The crew may look into the wet well for sticks and even observe that there is water in it.

Unfortunately this description of a lift station inspection is not uncommon even when performed by competent and well qualified operators. Daily visits tend to cause operators to give the station a quick glance in a noncritical manner because the crew was here yesterday and will be back tomorrow. For this reason, important maintenance items are often delayed until tomorrow which sometimes doesn't come for a month. Stations that are visited daily may be dirtier and more in need of maintenance than stations visited less frequently. If a lift station requires a daily inspection, the station book should have a daily task check off sheet indicating the tasks to be performed and a space for the initials of the operator who performed the task to indicate who did the job.

A very important aspect regardless of the frequency of visits is the fact that operating and maintenance operators must be provided the time and training to adequately perform each task. Also supervisors must occasionally inspect stations after a crew visit to see that the tasks were performed and not merely signed off. Once procedures and objectives have established that specified tasks must be done on a routine frequency (whether daily, weekly, monthly, quarterly or annually), the operators responsible for the lift station must accept the responsibility and be sure the task is completed when scheduled so the operation of the lift station will be as reliable as possible. Analysis of records can indicate if adjustments in the frequency of tasks are necessary.

Small communities with one or two lift stations may find it more economical to visit stations twice daily rather than to install and to maintain a telemetry system. When the operating agency has 15 to 50 lift stations to operate and maintain, then the time consumed for the single daily visit becomes very large and quite expensive. If it is possible to reduce station visits from once a day to once a week, the savings are substantial. Monthly station visits are practical, but visits at greater time intervals are not cost effective.

This chapter is not attempting to convince every operating agency to extend lift station visit frequencies, because this is not applicable to every station. It is attempting to indicate that many people have little confidence or no faith in their lift station's equipment and programs and do not believe that a station can operate a week, let alone 30 days by itself. Sacramento County, California, has been successfully operating lift stations with monthly visits for over fifteen years with relatively few problems. In fact there are fewer problems than when the stations were visited on a daily basis.

The following is a list of requirements that must be met to permit limited visits to lift stations of once a week to once a month.

1. Equipment lubrication reservoirs must be large enough to hold lubricant supplies to meet needs between visits to the station.
2. Telemetry of the station is required. Most lift stations constructed today are telemetered at least for the high water alarm. Usually other items may be sensed and alarmed on the same high water alarm signal, for example:
   a. Water level in sump pump pit of dry well,
   b. Power failure,
   c. Air compressor failure,
   d. Lift pump check valves, (When pump motor starts and check valve does not open, an alarm sounds indicating a pump failure.) and
   e. In stations using other auxiliary equipment necessary for station operation, the following additional items also may be sensed and telemetered:
      1) Water supply pressure,
      2) Chlorine leaks,
      3) Low chlorine pressure,
      4) High temperature of motors and engines, and
      5) Worker inside stuck elevator.

With the recent advances in solid state equipment, telemetered monitoring and supervisory control systems have become much more commonplace in collection systems. They range in complexity from very basic monitoring systems to more sophisticated computer-based alarm, telemetry, supervisory control, and flow-monitoring systems.

These systems consist of an electronic interface device located in the lift station which transmits alarm or monitored information via radio or over leased telephone lines. In some cases, an agency may run its own transmission lines; however, this currently is not common practice.

Information is received at a central location. This could be a 24-hour, seven-days-a-week dispatch center in the community such as the public safety office, or in the case of a utility that has their own 24-hour, seven-day-a-week dispatcher, to that office.

A simple system may be nothing more than an annunciator board that indicates the lift station and type of alarm. However, microcomputers are now frequently used in this application and perform logging functions to record various information such as date, time and nature of alarm.

In some systems the computer automatically polls various lift stations at a predetermined sequence and inquires the status of the station. If an alarm occurs, the computer can be programmed to automatically dial a preprogrammed number to a collection system operator and relay a message over the phone.

These monitoring and telemetry systems are frequently referred to as SCADA, which stands for Supervisory Control and Data Acquisition system. Figures 8.38 through 8.41 illustrate a recent state-of-the-art system that is utilized for monitoring lift station alarms, flow monitoring, rainfall information and river quality monitoring information. Figure 8.38 illustrates the components of the system.

Analog or digital inputs (AI, DI) are fed into a remote terminal unit (RTU) which is in fact a microprocessor located in the lift station. Information is transmitted over a leased telephone line, into a communication interface and ultimately into a mini-computer. Other auxiliary equipment include printers, XY plotters, video copier, fixed disc for memory and tape backup unit.

Although this is a fairly sophisticated system, its complexity is dictated by the numbers of field inputs and the needs of this particular agency. However, the basic concept would apply to small systems without the optional auxiliary equipment.

Figure 8.39 and 8.40 illustrate graphic information available to the dispatcher when a lift station alarm occurs and includes lift station number, flow meter number, time, date, alarm acknowledge indicator, power failure, transmission line failure, station power failure, standby generator running, high wet well, high dry well, pump 1 fail or pump 2 fail. The screen shows that flow is coming into the station through a bar screen and gives the actual flow reading occurring at the Parshall flume at the time of the alarm. The flume discharges into the wet well and the station has two pumps located in the dry well, as well as a standby generator permanently located at the site. The screen also indicates current station status.

Figure 8.41 is additional information that can be pulled up on the individual lift station and includes critical utility telephone numbers, who is responsible for the station, daily comments, what operator response is required and what dispatcher action was taken.

Virtually any type of alarm telemetry system improves the options available to the collection system operator when delegating personnel and equipment resources, particularly during emergency situations such as tornadoes, extremely high intensity rainfall, thunderstorms or other conditions which may leave the community and the collection system without utility power, or flooding or other emergency conditions.

If the collection system operator has a thorough knowledge of the system, a telemetered supervisory system which indicates station status will be invaluable in preventing backups and/or bypasses, station flooding or other severe problems in a collection system.

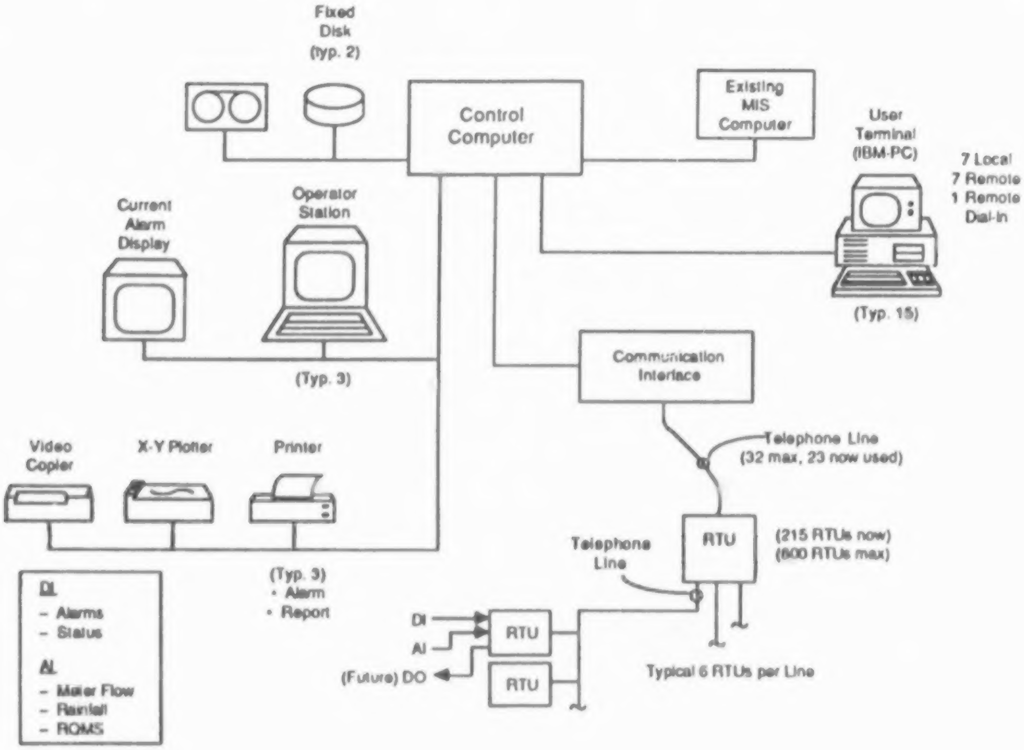

Fixed
Disk
(typ. 2)
Control
Computer
Existing
MIS
Computer
User
Terminal
(IBM-PC)
7 Local
7 Remote
1 Remote
Dial-In
(Typ. 15)
Current
Alarm
Display
Operator
Station
(Typ. 3)
Communication
Interface
Telephone Line
(32 max, 23 now used)
Video
Copier
X-Y Plotter
Printer
(Typ. 3)
• Alarm
• Report
Telephone
Line
RTU
(215 RTUs now)
(600 RTUs max)
DI
AI
(Future) DO
RTU
RTU
Typical 6 RTUs per Line
DI
– Alarms
– Status
AI
– Meter Flow
– Rainfall
– ROMS

Fig. 8.38 Components of a monitoring and telemetry system

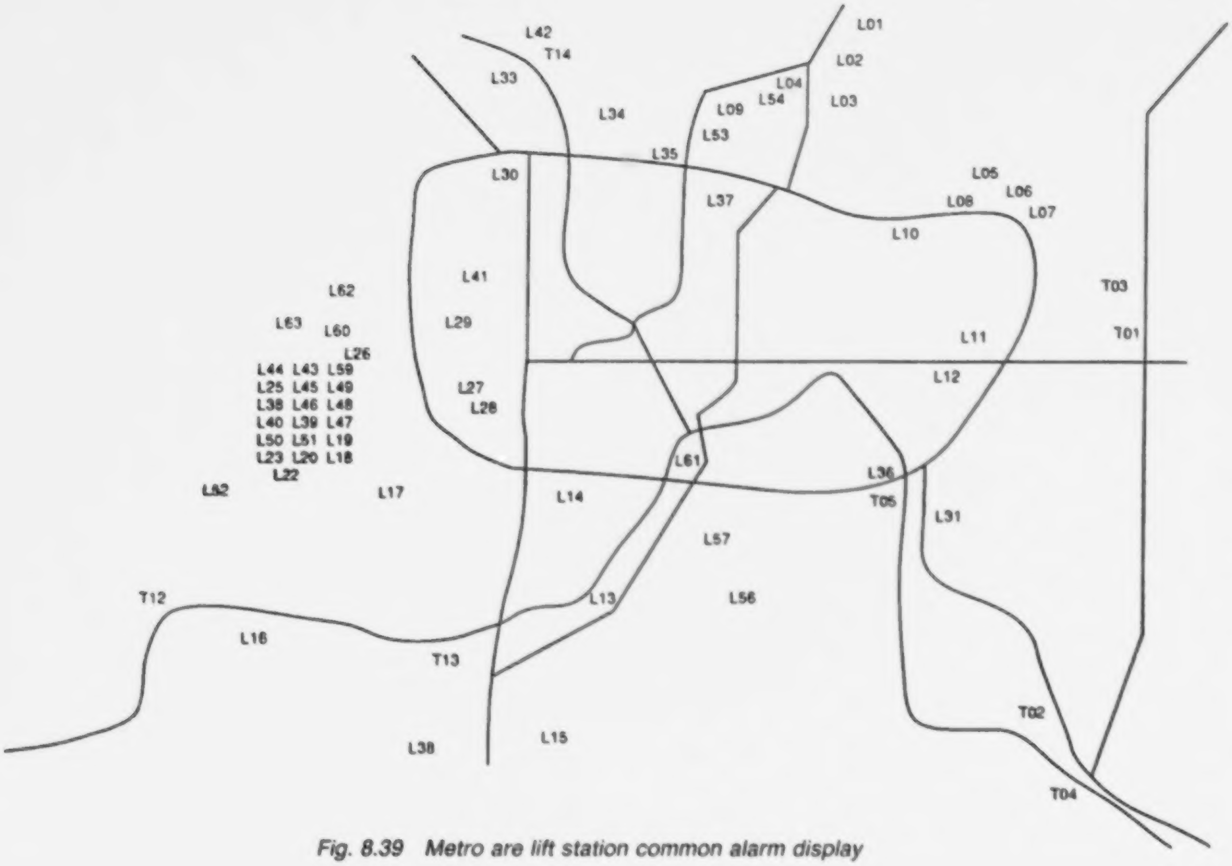
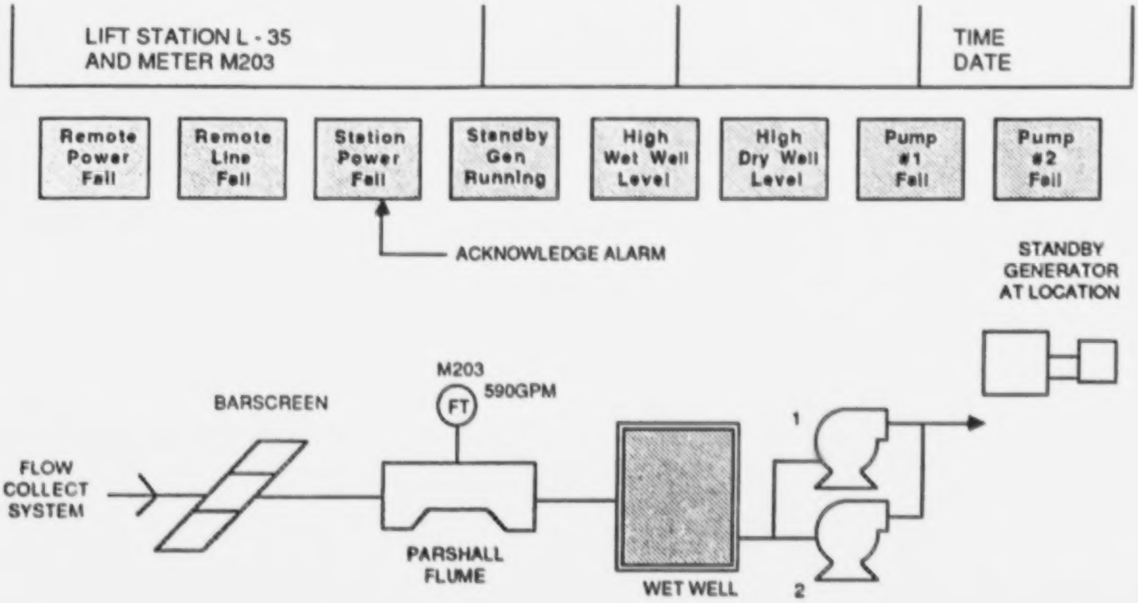
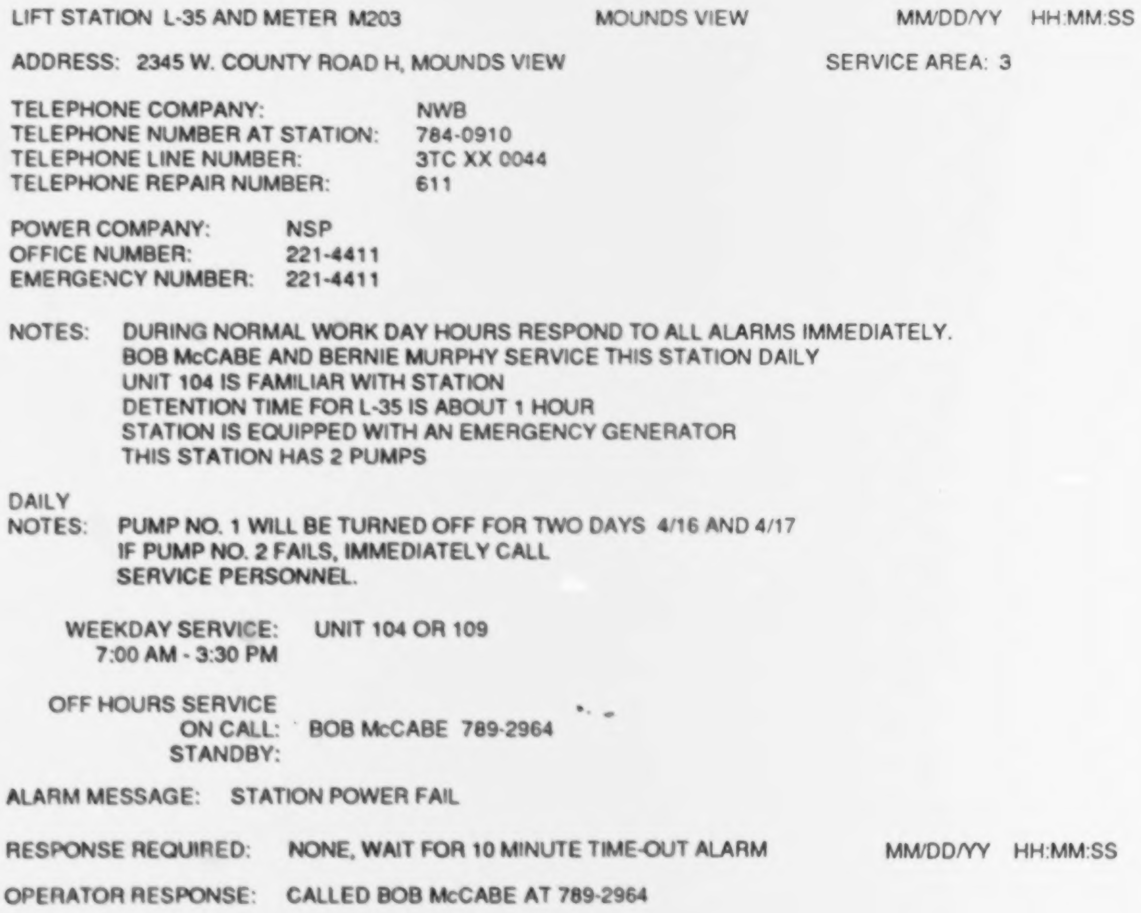

L42
T14
L01
L02
L04
L33
L34
L09
L54
L03
L53
L35
L30
L05
L06
L37
L08
L07
L10
L41
L62
T03
L63
L60
L29
L11
T01
L26
L44 L43 L59
L25 L45 L49
L38 L46 L48
L40 L39 L47
L50 L51 L19
L23 L20 L18
L22
L27
L28
L12
L61
L36
L52
L17
L14
T05
L31
L57
T12
L13
L56
L16
T13
T02
L38
L15
T04

Fig. 8.39 Metro are lift station common alarm display


LIFT STATION L - 35
AND METER M203
TIME
DATE
Remote Power Fail
Remote Line Fail
Station Power Fail
Standby Gen Running
High Wet Well Level
High Dry Well Level
Pump #1 Fail
Pump #2 Fail
ACKNOWLEDGE ALARM
STANDBY GENERATOR AT LOCATION
M203
590GPM
FT
BARSCREEN
FLOW COLLECT SYSTEM
PARSHALL FLUME
WET WELL
1
2

DAILY NOTES: PUMP NO. 1 IS TURNED OFF UNTIL 4/16.
IF PUMP NO. 2 FAILS, IMMEDIATELY CALL
SERVICE PERSONNEL.

Fig. 8.40 Typical individual lift station information



```
LIFT STATION  L-35 AND METER  M203              MOUNDS VIEW              MM/DD/YY    HH:MM:SS

ADDRESS:  2345 W. COUNTY ROAD H, MOUNDS VIEW                       SERVICE AREA:  3

TELEPHONE COMPANY:                   NWB
TELEPHONE NUMBER AT STATION:         784-0910
TELEPHONE LINE NUMBER:               3TC XX 0044
TELEPHONE REPAIR NUMBER:             611

POWER COMPANY:          NSP
OFFICE NUMBER:          221-4411
EMERGENCY NUMBER:       221-4411

NOTES:     DURING NORMAL WORK DAY HOURS RESPOND TO ALL ALARMS IMMEDIATELY.
           BOB McCABE AND BERNIE MURPHY SERVICE THIS STATION DAILY
           UNIT 104 IS FAMILIAR WITH STATION
           DETENTION TIME FOR L-35 IS ABOUT 1 HOUR
           STATION IS EQUIPPED WITH AN EMERGENCY GENERATOR
           THIS STATION HAS 2 PUMPS

DAILY
NOTES:     PUMP NO. 1 WILL BE TURNED OFF FOR TWO DAYS  4/16 AND 4/17
           IF PUMP NO. 2 FAILS, IMMEDIATELY CALL
           SERVICE PERSONNEL.

     WEEKDAY SERVICE:    UNIT 104 OR 109
       7:00 AM - 3:30 PM

    OFF HOURS SERVICE
             ON CALL:    BOB McCABE  789-2964
             STANDBY:

ALARM MESSAGE:    STATION POWER FAIL

RESPONSE REQUIRED:     NONE, WAIT FOR 10 MINUTE TIME-OUT ALARM          MM/DD/YY    HH:MM:SS

OPERATOR RESPONSE:     CALLED BOB McCABE AT 789-2964
```

Fig. 8.41 Telemetered alarm report

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 91.

8.4D What items or factors influence the frequency of lift station visits?

8.4E What are the different types of lift station failures?

8.4F How is the critical time for a lift station after failure determined?

8.4G When is a daily visit to a lift station required?

8.4H What requirements must be met for a lift station to perform effectively and only be visited from once a week to once a month?

8.43 Essential Tasks During Lift Station Visits

The only time a lift station should be visited is when it is toured by visiting dignitaries from out of town or by management inspecting the facilities. Neither of these two groups nor any other tour group tend to significantly add to the functional capability of a well maintained lift station. So as not to be misleading, let's define the term *VISIT*. There are two other types of station visits that are significant:

1. To perform scheduled routine preventive maintenance upon the equipment and the station, and
2. To respond to a lift station alarm or emergency condition to restore the station to operation.

If there is a *GOOD PREVENTIVE MAINTENANCE PROGRAM* and the *FREQUENCY SCHEDULE* is at the proper intevals with clear duty assignments in writing and completion verified by management, then there will be only a few occasions when a crew must respond to an alarm.

In this section we have attempted to convey a very important fact — wastewater lift stations can be capable of operating automatically. Proper maintenance will allow these stations to operate automatically for long time periods.

Why have many lift stations been visited daily? Probably because they were run by operators of wastewater treatment plants. Wastewater treatment plants are complex facilities requiring daily observation and regulation of treatment processes. Fortunately most small lift stations are not as complex and can be designed and maintained in a manner that allows the station to perform its functions automatically and without daily visits.

Note that the heading of this section is "Operation of Wastewater Lift Stations." Many stations can be operated automatically. The frequency of visits to a station depends on the equipment and station conditions. If a lift station overflows after five minutes of down time, this station may require an operator on duty at all times. The remainder of this section outlines what should be done to maintain the operational capabilities of a lift station.

8.430 Station Sign-In Log

Every lift station should have a sign-in log (Figures 8.42). The larger the operating agency, the more important a sign-in log becomes. Everyone who enters the station must sign in and log time of arrival and departure. This rule includes managers, supervisors and operation and maintenance operators. This practice reduces the number of mysterious changes in station operation such as pumps turned off, control system changes, station doors or gates left unlocked, and provides a method for reaching the appropriate person when corrective instructions need to be issued. The sign-in log produces a higher reliability factor in operator performance because operators do not wish to sign their name to a log at a given time indicating that they had made a station visit and a few minutes after their departure have a station fail because they had neglected a minor or major item. The station's sign-in log is kept inside the station on a small shelf or cabinet with the station book. When the last space is used on the sign-in sheet, that person or crew turns the sheet in to the agency office to be filed in the station book maintained at the office. New sign-in sheets are kept in the station as part of the preventive maintenance schedule. Some agencies use log books where agency operators sign in and record their activities at the station. The log books are generally maintained at the station for an entire year. Under these conditionss, the agency's management may not see these logs and may not be kept informed of station problems and conditions.

8.431 The Station Book

The station book is a loose leaf binder so that changes in the contents can easily be made, thus keeping the station's book up to date. The lift station book should contain the following information.

1. Station identification number.

   Most lift stations are given a name, such as "River Side" or "Park Road." In larger agencies and with the use of computer systems for cost accounting, stations are usually given a code consisting of letters and numbers (RS-25) for identification. This identification code must be used by operating and maintenance operators (see Section 8.6, Recordkeeping).

2. Map showing important facilities.

   This map should show location of lift station and force main, including valves, manholes, and discharge point of station force main. Other important features such as access route and other utilities are helpful.

3. Station description.

   This is a brief general description of the lift station and includes type, pump layout, control system and auxiliary systems.

4. Equipment data sheets.

   Detailed equipment data sheets that were completed during the lift station inspection after completion of construction are important. These sheets should contain name plate data and equipment operating characteristics.

SAFETY INSTRUCTIONS

PUMP STATION SIGN-IN LOG

DATE	IN	OUT	NAME	DATE	IN	OUT	NAME

Fig. 8.42 Station sign-in log

5. Safety instructions.

   Station safety instructions for working in the station and on its equipment are included in the book. These instructions must spell out specific hazards encountered in this specific lift station.

6. Emergency conditions.

   Action to be taken when an emergency occurs must be clearly outlined.

   Emergency conditons include:

   a. Power failure,

   b. Stoppage of inlet line,

   c. Simultaneous failure of pumps, and

   d. Flooding of dry pit.

   Critical time until homes or streets are flooded must be included. If auxiliary power generators are not part of the lift station, directions for obtaining one of adequate size and the minimum size should be included in the station book. Also included are procedures to electrically isolate the lift station and to connect a portable generator. If the station must be by-passed, the location of manholes for pump suction and discharge pipes, length and size of pipe required, and size of pump needed to pump around the station until repairs can be made must be in the station book.

7. Station preventive maintenance schedule.

   The lift station preventive maintenance schedule should contain every piece of station equipment and include the following information:

   a. Task description,

   b. Frequency each task is to be performed,

   c. If isolation of equipment is required, and

   d. Maintenance and/or overhaul instructions or number of paragraph containing instructions that apply to that station equipment or maintenance function which are scheduled for that visit.

Development of the station book is not any easy job and the book is not prepared overnight. The book is never completed, because it must be updated and revised due to changing flow conditions, equipment changes and modifications, and continuous attempts to improve operating and preventive maintenance programs.

When your first station book has been prepared, the chore becomes much easier for the next station, because most of the preventive maintenance and overhaul descriptions have been prepared for common equipment and only new equipment that is not in the program requires the development of maintenance procedures. The procedure described in this section has been developed over the past ten years and is continuously being expanded and improved.

8.432 Operation and Maintenance Duties

See Section 8.5, Lift Station Maintenance.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 91.

8.4I What are the types of significant lift station visits?

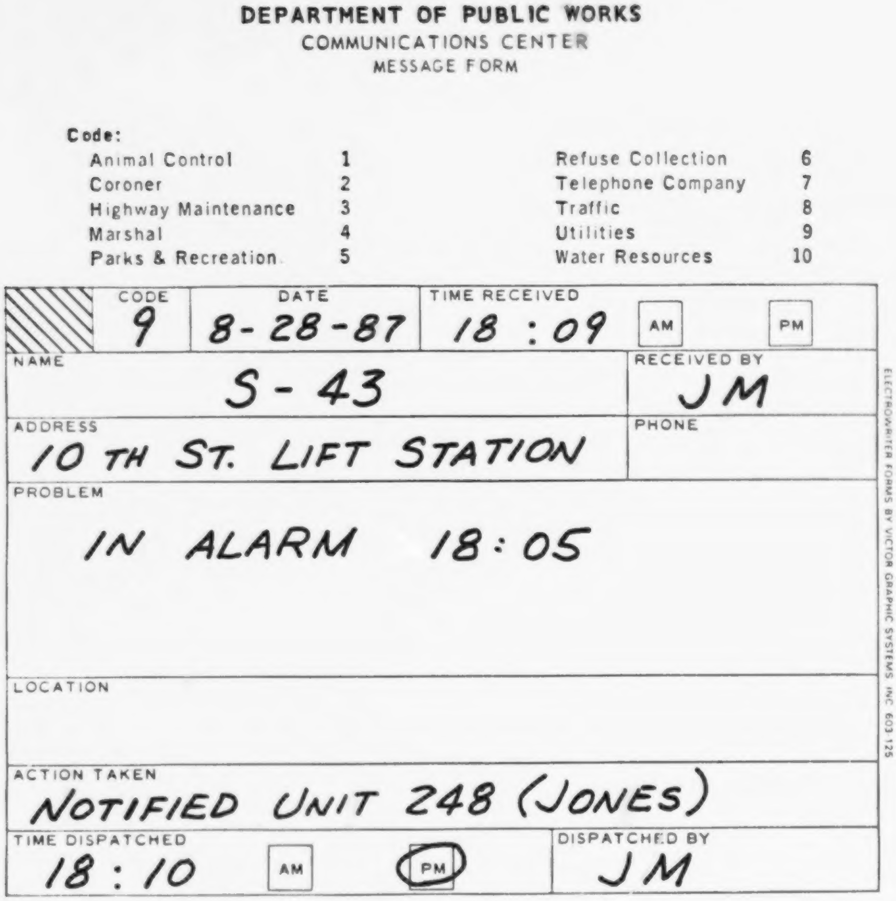
8.4J How can the number of responses to lift station alarms or emergency conditions be minimized?

8.4K Why should lift stations have a sign-in log?

8.4L What information is contained in the Station Book?

8.433 Responding to Station Alarms

Only a few agencies can afford or use telemetry systems that provide a dial or a meter with numbers that indicate the piece of equipment and nature of the problem in a remote lift station. Many agencies use telemetry alarm systems that transmit one signal that indicates either the lift station is operational or it needs to be visited. The signal is received at a facility that is manned twenty-four hours a day. In many cities this is the local police department or emergency dispatch center. When the station has a failure, the alarm is transmitted usually through leased phone lines to the manned center where a control panel will have an indicator light for the station that goes on when a problem develops. When the light goes on, a horn or some other type of noisy alarm will sound also. When trouble is indicated, the dispatcher notifies the operator on duty by phone or radio of the station identification number. The dispatcher must record on an appropriate log sheet the time and identification number of the station that sent the alarm signal. The time and name of the operator notified must be recorded too (see Figure 8.43).



DEPARTMENT OF PUBLIC WORKS
COMMUNICATIONS CENTER
MESSAGE FORM

Code:

Animal Control	1	Refuse Collection	6
Coroner	2	Telephone Company	7
Highway Maintenance	3	Traffic	8
Marshal	4	Utilities	9
Parks & Recreation	5	Water Resources	10

CODE 9	DATE 8-28-87	TIME RECEIVED 18 : 09 ☐ AM ☐ PM
NAME S - 43		RECEIVED BY JM
ADDRESS 10 TH ST. LIFT STATION		PHONE
PROBLEM IN ALARM 18:05		
LOCATION		
ACTION TAKEN NOTIFIED UNIT 248 (JONES)		
TIME DISPATCHED 18 : 10 ☐ AM [✓ PM]		DISPATCHED BY JM

ELECTROWRITER FORMS BY VICTOR GRAPHIC SYSTEMS INC 603-125

Fig. 8.43 Typical dispatcher's record

Usually during off-duty hours, the operator notified by the dispatcher picks up the other operator on the crew with an agency repair vehicle enroute to the problem lift station. When this emergency crew arrives at the lift station, the dispatcher should be notified and given an estimate of when the crew will call back in again. This procedure notifies the dispatcher that the crew has arrived at the lift station and protects the crew in case a serious injury occurs and they are unable to contact the dispatcher. If the crew does not call in again and the dispatcher cannot contact the crew, rescue operations can be started. During stormy and adverse weather conditions and especially at night, crews should be very cautious. Overhead power lines must be inspected *BEFORE* attempting to open the gates of a lift station. Fallen power lines across a chain link fence could electrocute a person trying to open a gate. When an emergency crew attempts to locate the cause of an alarm, they must inspect the station in the following sequence (also see Section 8.434, Typical Lift Station Problems):

1. Power supply to station.

   If lack of power supply to the station is the problem, the control center dispatcher should be notified by radio to request power company assistance in restoring power to the station. Dispatcher should determine estimated time of arrival of power company crew and then notify the field crew. Since lift stations are essential to the community's welfare, power companies place a high priority in restoring service. Some power companies provide special phone numbers for critical utility agencies to use in emergencies to contact their dispatchers in order to restore power as soon as possible to the area where the station is located.

2. Open access to dry well side of station and inspect:
   a. Interior lighting, and
   b. Operation of ventilation equipment.

If the interior lighting in the station is out, use flashlights from the repair truck.

If the ventilation equipment is off, measure the atmosphere in the lift station and work areas for sufficient oxygen and the presence of explosive and toxic gases. Continue to test the atmosphere in the station until the ventilation equipment has been returned to operation for at least 30 minutes.

If during the test of the station atmosphere the gas detection meter indicates an adverse condition, the crew must leave the station dry well and ventilate the dry well area with a portable blower. If the station must be entered to correct a serious problem, additional help must be requested. Also needed will be a safety harness and self-contained breathing equipment for reentry to the station under hazardous conditions.

3. Station well pit areas.

Examine this area carefully to be sure that all levels of the dry well area are not flooded *BEFORE* restoring high voltage power to operating equipment if power is out.

If electrical motors are flooded and/or will not start, open main power switches to lower area electrical circuits. Request help in setting up emergency pumping equipment. Locate and repair leak to dry pit. Pump the water out of the dry pit with portable pumps. Conduct electrical megger checks (see Chapter 9, Section 9.23, Tools, Meters and Testers) on electrical circuits and motors that were flooded to make sure they can be operated, or they must be removed and repaired.

4. Motor control center and power panel.

If the dry well area is not flooded and equipment looks normal (no broken pump shafts, pumps not rotating backwards, check valves closed and seated), then return to the motor control center and power panel.

NOTE. In some lift stations, full power may be restored to all operating equipment at one time. In other stations, especially where large pumps are used, the equipment should be put back on line one unit at a time.

The station book should have the proper starting sequence for all of the station equipment. A good practice is to open equipment breakers and bring the station back on line by starting one unit at a time. A suggested starting sequence is as follows:

a. Station lights,

b. Station ventilation equipment,

c. Station sump pumps,

d. Station control system (air compressors),

e. Essential station auxiliary system (water wells and hydraulic system pumps),

f. Station last pump to start,

g. Station second pump,

h. Station lead pump, and

i. All station systems.

As each piece of equipment is restored to service it should be inspected for proper operation, lubrication, and if appropriate, operating pressures and flow rates. The station book should indicate the operating ranges of the equipment.

The reason for bringing the last pump on first, the second pump next, and the lead pump last is that this procedure provides each unit with the opportunity to operate and to be inspected before the wet well level returns to normal levels. If the lead pump is started first, the wet well level may fall quickly; and by the time the crew is ready to test run the last pump, the wet well level is too low for automatic operation of the pump. The pump may be inspected in the manual mode of operation, but this does not guarantee it will function in the automatic sequence.

5. Wet well.

If the wet well is flooded and has inlet gates, the gates should be closed or throttled in order to store wastewater in the gravity portion of the collection system until the wastewater level in the wet well can be restored to normal elevations. The station book should list the procedure for closing the inlet gates and specify the critical time the gates can remain closed before damage will result from flooding.

6. After alarm condition has been corrected.

Before the crew departs from the station, they must make sure that all equipment is functioning properly or that damaged equipment is isolated and the station will perform until repairs are made. The following tasks should be completed before leaving the station:

a. Station restored to service,

b. All equipment inspected,

c. Station problem and correction recorded in station book along with identification of crew doing repairs, and

d. Contact dispatcher to verify that alarm condition is cleared from telemetry alarm panel.

7. Report.

Complete a report form listing crew members, vehicle and equipment numbers, time dispatched, time of arrival at station, work performed, and time of departure from station.

8. Secure lift station.

Lock lift station and yard gates. Contact dispatcher for next assignment.

When a crew responds to a lift station alarm, the worst possible conditions should be expected. Extreme caution must be exercised by the crew for their own safety, as well as for protection of the equipment and the station. Any number of serious problems may be encountered from downed power lines and/or flooding to broken pipes, valves, or pump shafts. Chlorine leaks can develop if chlorine is applied at the lift station. A coiled rattlesnake on the third step down to the lower pump room is a possible hazard in some areas.

8.434 Typical Lift Station Problems

Lift station problems may be listed in the following four categories:

1. Power
    - a. Power failures.
    - b. Electrical circuit failures.
        - 1) Thermal overloads tripped.
        - 2) Fuses blown.
        - 3) Relays burned out.
    - c. Motors burned out.
2. Control systems
    - a. Telemetry system failure.
    - b. Wet well controller.
        - 1) Float type
            - a) Float stuck in stilling well,
            - b) Float line broken.
            - c) Power off and cam overrode stops.
            - d) Mercury switches failed.
        - 2) Bubbler type
            - a) Air compressor failed.
            - b) Bubbler line plugged or restricted.
            - c) Leak in air piping system.
            - d) Diaphragm ruptured.
            - e) Mercury switches failed.
            - f) Condensed water in air lines.
            - g) Bubbler line broken off in wet well.
        - 3) Electrode systems
            - a) Short in electrode leads.
            - b) Electrodes coated with grease or rags.
            - c) Electrodes tangled when wet well changes levels.
        - 4) Seal trode units
            - a) Bulb ruptured.
            - b) Electrolyte leaked out.
            - c) Short in electrode leads.
3. Pumping systems
    - a. Pump impeller plugged with rags or sticks.
    - b. Pump suction blocked.
    - c. Check valve stuck open or flap broken from shaft.
    - d. Pump drive shaft from motor broken.
    - e. Failure of packing gland or seal water supply.
    - f. Pump air- or gas-bound.
4. Structures
    - a. Grit deposits in wet well.
    - b. Grease and floating debris in wet well.
    - c. Force main restricted or plugged.

Most of these problems can be prevented through a good preventive maintenance program.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 92.

8.4M How is an alarm situation transmitted from a lift station to a dispatcher at a control center?

8.4N Why should an emergency crew at a lift station notify the dispatcher when they will call in again?

8.4O Why should overhead power lines be inspected by emergency crews upon arrival at a lift station?

8.4P What are the major categories of lift station problems?

END OF LESSON 4 OF 5 ON LIFT STATIONS

DISCUSSION AND REVIEW QUESTIONS

Chapter 8. LIFT STATIONS

(Lesson 4 of 5 Lessons)

Write the answers to these questions in your notebook before continuing. The problem numbering continues from Lesson 3.

17. What action would you take if a lift station failed and the wastewater in the collection system was rising rapidly?
18. How would you determine the frequency of visits to a lift station?
19. Discuss the advantages and limitations of daily versus weekly to monthly visits to lift stations.
20. How would you respond to a lift station alarm failure and how would you attempt to locate or identify the cause of the failure?
21. What would you do during a lift station visit (what items should be inspected)?
22. What types of books or records should be kept in a lift station? Why?
23. What safety precautions would you take *BEFORE* attempting to determine the cause of a lift station failure?
24. What kinds of problems or failures can occur in lift stations?

CHAPTER 8. LIFT STATIONS

(Lesson 5 of 5 Lessons)

8.5 LIFT STATION MAINTENANCE

Chapter 9 of this manual describes *EQUIPMENT MAINTENANCE PROCEDURES*. The intent of this section is to describe how to establish a maintenance *PROGRAM* and a frequency *SCHEDULE FOR LIFT STATIONS*. The maintenance program consists of two major parts:

1. Scheduling the work.

   Necessary work must be scheduled in advance and must include items that must be performed during a given time period.

2. Performing the work.

   Maintenance work must be performed in a specific manner. Every task must be done the same way by every operator.

Both scheduling and performing are important, but the development of a schedule is the most difficult job. Insuring consistent procedures for performing the work is accomplished by providing the operators with written instructions, proper training, necessary tools and evaluation of completed work by supervisors.

8.51 Scheduling Maintenance

Preparation of a lift station maintenance program requires consideration of three important factors:

1. Recommendations of equipment manufacturers,
2. Requirements of lift station, and
3. Knowledge previously gained from experience by the operating agency.

8.510 Recommendations of Equipment Manufacturers

Equipment manufacturers provide maintenance and overhaul recommendations for each piece of equipment they install in a lift station. Usually this information is contained in a convenient binder or manual. Information includes frequency of oil changes and lubrication of bearings, types of lubricants, operating temperature ranges, pressures, flow rates, and disassembly procedures for specific equipment maintenance or parts replacement.

During the first year of operation of new equipment, the manufacturers' recommendations must be closely followed to maintain equipment warranties. The equipment maintenance schedule is developed by listing all of the manufacturers' recommendations in sequence according to time periods, such as daily (D), weekly (W), monthly (M), quarterly (Q), semiannually (SA), and annually (A) according to when these functions or tasks are to be performed.

When all of the equipment in the station and the frequency of each maintenance task has been tabulated, then the procedures for performing the tasks should be indexed. If you do not have a standard procedure, refer to the manufacturers' recommendations. Many tasks follow the same procedure regardless of the manufacturer of the equipment. For example, adjustment of packing glands, *LUBRIFLUSHING*[10] motor and pump bearings, or alignment of drive couplings usually follow the same procedures, even though the tolerance specifications may be different.

8.511 Lift Station Requirements

Each individual lift station may have different requirements. These differences result from the design and location of the station. The items listed here are the tasks that are required to be performed at given frequencies to keep the station operating. These items should be developed primarily from station operating experience and should be reevaluated annually by field operators, supervisors and management. Reevaluation includes changes in frequency of tasks, operational methods, or lift station revisions or redesign in order to increase station reliability and reduce station failures, alarms and crew work loads.

For example, let's examine the situation where a lift station uses a bar screen, a pump operation control system using a stilling well and float, and the lift station is serving a community with several restaurants which produce an excessive grease load on the station. These conditions cause the station's maintenance demands to be higher than necessary because of the following conditions:

1. The bar screen should be cleaned daily or at least two or three times a week.
2. Grease will create operational problems with the float travel in the stilling well. Hosing and flushing of the stilling well will be required once or twice a week.
3. The wet well will have to be cleaned quarterly instead of annually due to the excessive grease. Clean the wet well walls manually, or use a high velocity cleaner to wash down the wet well walls to prevent grease buildup and the generation of hydrogen sulfide. If the grease is not thoroughly removed regularly, the wet well concrete walls will deteriorate and could require patching and protective coatings within five years.

What kinds of alternatives or choices are available? You may not have any and may be forced to schedule the frequent visits to this particular lift station. Or you may have some of the following options:

1. Remove the bar screen and allow the station to operate without it. If piping system or pump starts plugging, the bar screen can be replaced. Hopefully the station will operate without problems after the bar screen is removed.
2. Enforce the local sewer-use ordinance and have the discharger remove the grease at the source and thus prevent the grease from entering the collection system.
3. Record each station alarm and the cause of the failure. Estimate the cost of labor, equipment and materials to correct each failure. Determine the best solution by comparing costs of repairs with cost of a more frequent and extensive maintenance program and possibly more alarm calls. Consideration also must be given to your objectives, such as reducing stoppages and odor problems.

Remember that flows usually increase in the future and wastewater characteristics also change. In many cases maintenance requirements of wet wells and force mains are greater on new lift stations handling low flows because detention times in wet wells and force mains can become very long. When flows through a new lift station increase, conditions may improve and the frequency of performing certain maintenance tasks can and should be reduced. Field crews should be able to make important contributions to decisions regarding the frequency and types of maintenance tasks required by a lift station. These crews are familiar with the station, notice changing conditions, and are capable of comparing conditions and operational characteristics with other lift stations.

8.512 Knowledge Gained from Experience

A very important factor in maintenance scheduling is the knowledge and experience gained by an agency regarding how to deal with local conditions, ability of operators to perform tasks and reliability of existing equipment. The major problem with applying knowledge and experience is that occasionally procedures other than those recommended by the manufacturer appear better. Remember that the manufacturer prepared the manual for use throughout the world and not for your specific conditions and problems. Perhaps the recommended lubricant will not perform satisfactorily due to high or low temperatures in your area. Dust conditions or humidity may require equipment protection filters to be changed at twice the recommended frequency or possibly the filter life can be extended three months longer than recommended. If lift station wet wells can be safely cleaned only in

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[10] *Lubriflushing (LOOB-rah-FLUSH-ing). A method of lubricating bearings with grease. Remove the relief plug and apply the proper lubricant to the bearing at the lubrication fitting. Run the pump to expel excess lubricant.*

July and August, don't schedule cleaning during February when there is three feet of snow on the ground and the temperatures are below freezing.

8.52 The Actual Maintenance Schedule

The supplement to this chapter consists of pages from a typical lift station (identification code S-14). The purpose of this supplement is to illustrate a preventive maintenance program in a station book. This lift station is visited once a month for scheduled maintenance. See page 411.

8.520 Crew Notification of Required Maintenance

Once the preventive maintenance is established, there must be a procedure that notifies a crew to perform the required maintenance at the station. There also must be a method of recording when the work is completed by field crews. This information should be checked off against the scheduled work and filed in the lift station book in the main office. If maintenance items are overlooked or not performed, they must be rescheduled and completed.

One method of insuring that work gets completed is by the use of a form such as the one shown in Figure 8.44. This form has a hard copy and two soft copies. The forms are produced each month and one month before the tasks are scheduled to be performed by the agency office staff using an addressograph plate that is coded to a specific time schedule or interval — weekly, monthly, quarterly, semi-annually, annually, two years and five years. The forms are produced by the addressograph machine with the maintenance functions that must be performed during each month at each facility as shown in Figure 8.44.

The top soft copy of the form is retained in the office with a soft and hard copy going to the supervisors of the field crews. The supervisors assign the maintenance jobs required at each lift station to the field crews who do the work. The form contains the tasks to be performed and the sections in the maintenance and overhaul manual where the task directions and instructions are located. The maintenance and overhaul manual is developed from the manufacturers' instructions and the operating agency's actual experience in maintaining and overhauling the various types of equipment.

When new stations are placed in service, the equipment maintenance procedures are obtained from the appropriate paragraphs in the existing maintenance and overhaul manuals. If new equipment requires different maintenance items or procedures than those already in the existing manual, new instructions are prepared and inserted in the station book and in the field crews' maintenance and overhaul manuals. When a specific maintenance item or job is scheduled, the form (Figure 8.44) will show the section of the maintenance and overhaul manual where the directions are located that specify how to perform the scheduled work.

8.521 Recording Completed Work

When each task is completed, the crew leader signs it off. When the work has been completed and the form filled out, it is returned to the office where it is matched with the cover copy. A match-up of work required with work completed indicates that the scheduled work was done. On the bottom of the form is an area for comments so that if a field crew finds a discrepancy or a pending problem, it is noted and brought to the attention of a supervisor for corrective action.

Not shown on the station book are preventive maintenance jobs scheduled for two to five-year intervals. These jobs include equipment overhauls and lift station painting.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 92.

8.5A What are the two major parts of a maintenance program?

8.5B Why should equipment manufacturers' recommendations be followed, especially during the first year?

8.5C Why are maintenance requirements sometimes greater for new lift stations with low flows than with older stations with greater flows?

8.5D Why should field crews be allowed to contribute to decisions regarding the frequency and types of maintenance tasks required by a lift station?

8.5E Why should a form showing work completed be compared with the work assignment?

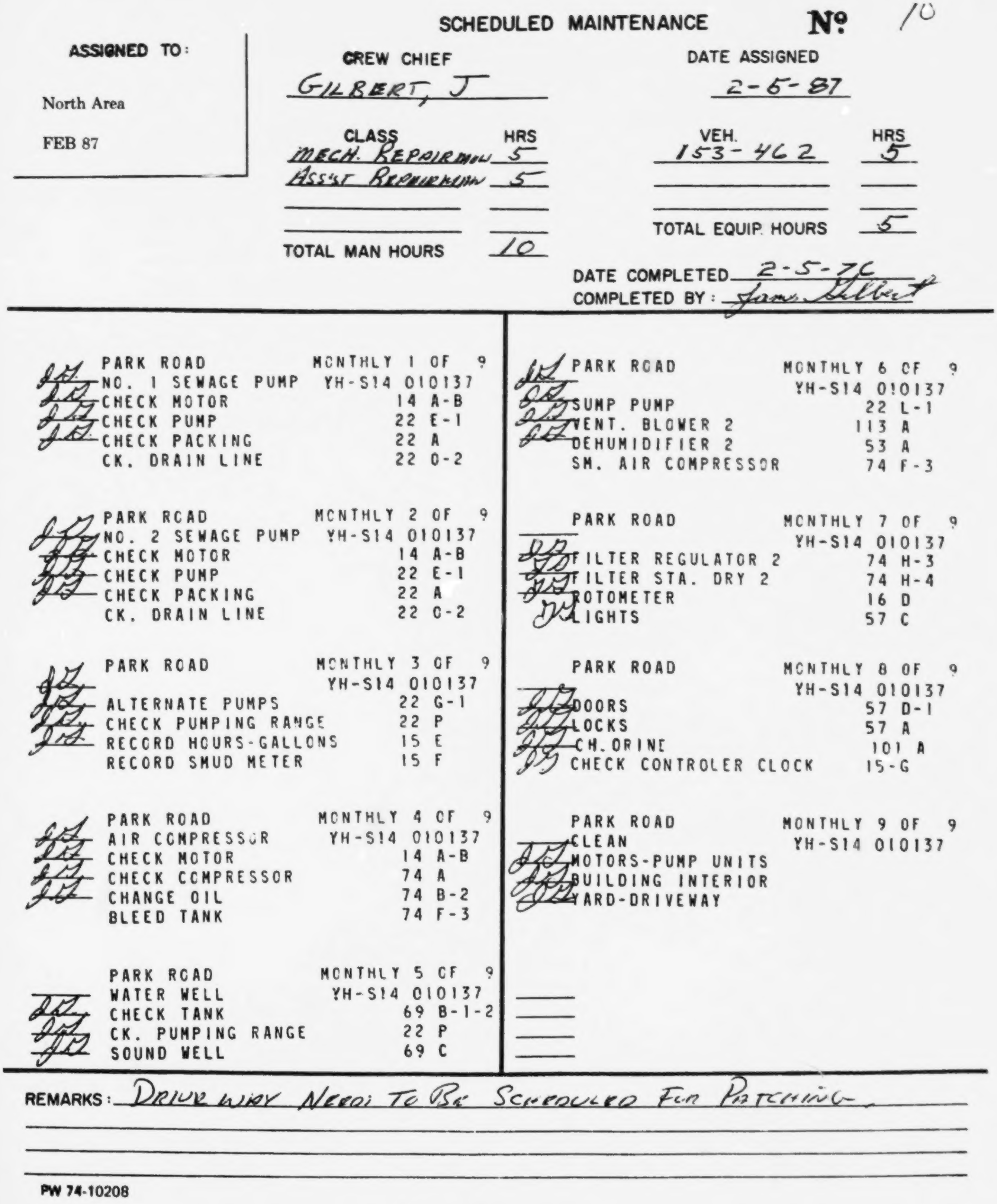
8.6 RECORDKEEPING

8.61 Filing of Records

Records are an important part of a lift station operation and maintenance program. They should be filed at the agency's main office. Records left in the lift station are of little value to supervisors or managers. Frequently records left in lift stations get lost or misplaced. Active records (this year) should be kept in the office copy of the station book. This procedure keeps all information at one source. At the end of each operating year or the end of a designated period selected by the agency, the past year's operational and maintenance records are removed from the station book and placed in a station file. This method keeps the station book at the office from becoming too bulky and keeps only pertinent data in the book for the station's operation and maintenance programs.

8.62 Cost Records

Records maintained on each lift station should show at least the costs of operating and maintaining the facility. The costs include the following:



SCHEDULED MAINTENANCE **№** 10

ASSIGNED TO:
North Area
FEB 87

CREW CHIEF GILBERT, J

DATE ASSIGNED 2-5-87

CLASS	HRS
MECH. REPAIRMAN	5
ASS'T REPAIRMAN	5
TOTAL MAN HOURS	10

VEH.	HRS
153-462	5
TOTAL EQUIP. HOURS	5

DATE COMPLETED 2-5-76
COMPLETED BY: James Gilbert

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PARK ROAD             MONTHLY 1 OF  9
NO. 1 SEWAGE PUMP   YH-S14 010137
CHECK MOTOR                14 A-B
CHECK PUMP                 22 E-1
CHECK PACKING              22 A
CK. DRAIN LINE             22 O-2

PARK ROAD             MONTHLY 2 OF  9
NO. 2 SEWAGE PUMP   YH-S14 010137
CHECK MOTOR                14 A-B
CHECK PUMP                 22 E-1
CHECK PACKING              22 A
CK. DRAIN LINE             22 O-2

PARK ROAD             MONTHLY 3 OF  9
                     YH-S14 010137
ALTERNATE PUMPS            22 G-1
CHECK PUMPING RANGE        22 P
RECORD HOURS-GALLONS       15 E
RECORD SMUD METER          15 F

PARK ROAD             MONTHLY 4 OF  9
AIR COMPRESSOR       YH-S14 010137
CHECK MOTOR                14 A-B
CHECK COMPRESSOR           74 A
CHANGE OIL                 74 B-2
BLEED TANK                 74 F-3

PARK ROAD             MONTHLY 5 OF  9
WATER WELL           YH-S14 010137
CHECK TANK                 69 B-1-2
CK. PUMPING RANGE          22 P
SOUND WELL                 69 C
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PARK ROAD                  MONTHLY 6 OF  9
                            YH-S14 010137
SUMP PUMP                        22 L-1
VENT. BLOWER 2                  113 A
DEHUMIDIFIER 2                   53 A
SM. AIR COMPRESSOR               74 F-3

PARK ROAD                  MONTHLY 7 OF  9
                            YH-S14 010137
FILTER REGULATOR 2               74 H-3
FILTER STA. DRY 2                74 H-4
ROTOMETER                        16 D
LIGHTS                           57 C

PARK ROAD                  MONTHLY 8 OF  9
                            YH-S14 010137
DOORS                            57 D-1
LOCKS                            57 A
CHLORINE                         101 A
CHECK CONTROLER CLOCK            15-G

PARK ROAD                  MONTHLY 9 OF  9
CLEAN                       YH-S14 010137
MOTORS-PUMP UNITS
BUILDING INTERIOR
YARD-DRIVEWAY
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REMARKS: DRIVE WAY NEEDS TO BE SCHEDULED FOR PATCHING.

PW 74-10208

Fig. 8.44 Maintenance task forms

1. Electrical power cost,
2. Fuel costs such as gasoline, diesel, natural or bottled gas,
3. Operational and maintenance costs on basis of labor, vehicles, equipment and supplies, including water and chlorine used,
4. Scheduled preventive maintenance and repair costs on basis of labor, parts, shop expenses, vehicles, tool and equipment rental, paint, lubricants and other supplies,
5. Unscheduled repair costs, including responding to the station telemetry alarms, power failures and other problems that require a visit to the station that was not regularly scheduled, and
6. Repair costs to station caused by vandalism or accidents. Record whether or not the costs of the repairs were recovered from individuals who caused the damage.

Record all goods received. A simple and convenient log sheet is as follows:

Date Goods Received	Order Number	Description of goods	Cost	Date Bill Received

When a bill is received, be sure that the goods were received and that the order is complete before paying the bill. Sometimes orders are delivered that are not complete; and when a bill arrives six months after the goods were received, it can be difficult to remember if the order was complete.

By keeping accurate cost records, these costs for operating and maintaining the station provide the information needed to prepare next year's annual budget. Cost data on a lift station may be kept in the office of a supervisor where the supervisor is expected to maintain up-to-date records or the information may be recorded on forms supplied by the agency's accounting division.

8.63 Station Identification Number

Auditors and computer people seem to delight in using long strings of numbers and letters for identification purposes. They cannot accept obvious descriptive names such as "Park Road" or "Riverside" for lift stations. By using letters and numbers, they describe the "Park Road" lift station as "L14." "L" indicates lift and 14 is the number assigned to the Park Road facility. Riverside lift station may be identified as L68. Money from the budget to operate the station is assigned a work authorization number so that L14 becomes L14-010691 and Riverside is L68-011274. This code or designation only indicates at which facility and when the money is available. By adding an activity code, you can identify how the money is spent. For example, a typical list of activity codes is as follows:

GX = Operations

YH = Scheduled preventive maintenance

YZ = Unscheduled repairs

AA = Responding to telemetry alarms or emergency conditions

PE = Electrical power charges

PD = Purchase of diesel fuel

PN = Purchase of natural gas

PG = Purchase of gasoline

PC = Purchase of chlorine

XC = Delivery of chlorine

PC
PG
YH
GX
YZ
PE
PD
XC
PN
AA

Depending upon the system and agency, the activity code list may consist of a hundred or more items. A list this long can become a bother, if not confusing to field operators. If the proper identification code is not used by field operators, then the accounting system is of little use because one station may be charged with costs from another station. Therefore, any agency wishing to use a computer accounting system effectively must use a simple system that field operators understand and use.

If a crew is making a visit to the Park Road lift station for an operational inspection, they would record their time as:

1.80 hours GX – L14-01069

If another crew was performing scheduled preventive maintenance at the Riverside station, they would record their time as:

6.50 hours YH – L68-011274

Computer systems can become very complex, depending on the size of agency, information desired from the computer, and number of agencies using the computer. The computer can provide printouts at regular frequencies that show data on costs for manpower, energy, equipment, materials, parts, lubricants and supplies. This information goes to a supervisor who must determine if the operation and maintenance programs are effective and are not overrunning the budget.

8.64 Other Records

Records other than cost data that are important include the items listed in this section.

8.640 Preventive Maintenance Schedule for Lift Stations

The equipment and preventive maintenance schedule for tasks to be performed on a monthly, quarterly, semiannual and annual basis must be properly identified. When this work has been completed and signed off by the appropriate crews, the forms should be filed in the station book at the office.

8.641 Unscheduled Work Order Requests

A report form for unscheduled work shows the type of unscheduled work, why it was performed, and the costs, including labor, equipment and materials. Also the form should indicate where materials were bought and where used to perform the job or repairs.

8.642 Modifications Made to the Station or Force Main

All drawings and plans must be kept up to date to facilitate future work and to evaluate station performance.

8.643 Written Reports

Especially important are written reports providing details of unusual conditions or repairs made to the lift station. These reports should indicate how repairs were made, time required, unusual conditions encountered, special equipment or materials needed, or additional maintenance scheduling required in case the job needs special attention or must be repeated in the future. Unfortunately we sometimes have to do jobs in the future that are similar and no one is available who remembers exactly how a previous job was done or the problems encountered.

8.644 Operational Data

Important operational data includes flow records, equipment lapsed time meter readings, chlorination rates, and other operating data that may be required by your agency.

8.7 SUMMARY

We hope this chapter has stimulated some thought regarding the operation and maintenance of wastewater lift stations. Our experience has shown that proper design and maintenance are the key to lift station reliability. Lift stations can effectively operate themselves if given the opportunity and care they need.

QUESTIONS

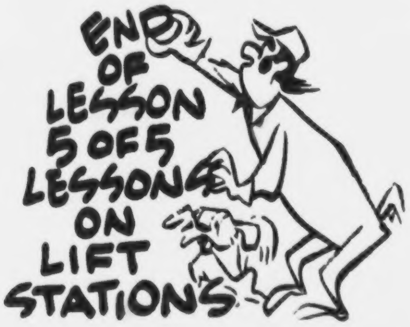
Write your answers in a notebook and then compare your answers with those on page 92.

8.6A Why should records of a lift station not be filed in the lift station?

8.6B What items should be included in lift station costs?

8.6C Why are activity codes used in accounting or to keep track of lift station costs?

8.6D Why should reports be written detailing how repairs are made?


END OF LESSON 5 OF 5 LESSONS ON LIFT STATIONS

DISCUSSION AND REVIEW QUESTIONS

Chapter 8. LIFT STATIONS

(Lesson 5 of 5 Lessons)

Write the answers to these questions in your notebook before continuing with the objective test on page 408. The problem numbering continues from Lesson 4.

25. How would you develop a maintenance schedule for a lift station?
26. Why should a maintenance schedule be reviewed from time to time?
27. If a grease problem develops in a lift station, review the advantages and limitations of the different possible solutions to the problem.
28. What records would you keep of a lift station and how and where would you file them?
29. Why are lift station costs important?
30. What types of written reports should be prepared for lift stations? Why?

SUGGESTED ANSWERS

Chapter 8. LIFT STATIONS

ANSWERS TO QUESTIONS IN LESSON 1

Answers to questions on page 9.

8.1A Wastewater is raised or lifted in a lift station by centrifugal pumps or pneumatic ejectors.

8.1B The location of lift stations is influenced by excavation costs to maintain gravity flow. Excavation costs are affected by:

1. Depth of sewer,
2. Soil stability and rocks,
3. Level of groundwater table,
4. Location of other utilities, and
5. Surface or overhead structures.

8.1C The two major safety items that must be considered around lift stations are:

1. Safety of operation and maintenance operators, and
2. Safety of public.

Answers to questions on page 19.

8.1D A submersible pump is often installed in a wet well.

8.1E A limitation of a pump installed in a wet well is limited access to the pumping equipment, thus creating a problem when the pump has to be repaired.

Answers to questions on page 24.

8.1F The most desirable operational situation for a wet well is when all the flow and solids that discharge into the wet well from the gravity sewer are lifted to the higher elevation and continue to the wastewater treatment plant without delay.

8.1G Static head is the difference between the water surface elevation in a wet well on the suction side of a pump and the water surface elevation on the discharge side of a pump. Dynamic head is the difference in elevation between the energy grade line on the suction side and the discharge side of the pump. The dynamic head is the static head plus the friction or energy losses that result from water flowing through the pipes, valves and fittings in the lift station.

8.1H Friction losses are caused by water flowing through pipes, valves and fittings in a lift station. The greater the velocity of the flowing water, the greater the friction losses.

ANSWERS TO QUESTIONS IN LESSON 2

Answers to questions on page 27.

8.2A Pumps should not start and stop frequently in lift stations because frequent motor starts cause excessive wear on equipment and may cause surges in the wastewater flow.

8.2B If a wet well is too large, wastewater is stored too long and solids will settle out. This creates the opportunity for the wastewater to turn anaerobic and produce hydrogen sulfide and odors and methane.

8.2C The main advantage of variable-speed pumping equipment is that the pumping rate can be adjusted to meet the inflow rate.

Answers to questions on page 34.

8.2D Bar racks usually are not used in lift stations pumping only domestic and industrial wastewaters because:

1. Screenings are a problem to remove and to transport to a disposal site, and
2. Pumping units are equipped with open impellers or closed two-port impellers sized to pass most solids found in the collection system.

8.2E Sump pumps in dry wells are used to remove excess water, such as seal water leakage and cleanup water.

8.2F When a seal fails on a submersible pump, wastewater can leak into the motor compartment and the unit will shut itself off.

Answers to questions on page 38.

8.2G The two types of float controllers are:

1. Rod-attached to floats, and
2. Steel tape-, cable-, or rope-attached to floats.

8.2H If the upper stop on the float rod is raised, the wet well will be pumped farther down, because the float will have to be dropped lower before the pump will shut off.

8.2I Maintenance on a stilling well includes removing grease and debris that hinder or stop the up-and-down movement of the float. Other maintenance or repairs include float attachment line breaking or unwinding from drum sheave and float developing a leak.

Answers to questions on page 42.

8.2J Controls used to start, stop or change pumping rates include float controllers, electrode controllers and pressure-sensing controllers.

8.2K Electrical safety regulations must be complied with when using electrode controllers. Be sure that power to the electrodes is turned off and properly tagged before performing any maintenance on the equipment. Operators should be cautioned not to touch electrodes with bar screen rakes or other tools.

8.2L Limitations of electrode controllers include:

1. Rags and debris can wrap around electrodes and alter desired pump start and stop level in a wet well, and
2. Grease and/or slime can cover an electrode, thus preventing good conductivity and causing intermittent or unreliable operation.

8.2M Pressure-sensing controllers detect pressure changes by measuring the back pressure required to overcome the pressure created by the level of the water above the outlet of the bubbler.

8.2N Problems that can develop using seal trode sensing controllers include:

1. Bulb can break,
2. Shorts occur in electrode wiring, and
3. Bulb life is 3 to 5 years.

8.2O Pressure-sensing controllers measure depth of water in a wet well on the basis of air pressure or back pressure in the air bubbler line.

8.2P Problems that can develop with pressure-sensing controllers include:

1. Air compressor failure,
2. Bubbler blockage, tube breakage, or outlet elevation shifts,
3. Many opportunities for equipment failure, and
4. Need for a higher level of training for operators to troubleshoot, repair and keep instruments calibrated.

Answers to questions on page 62.

8.2Q Lift stations should be equipped with at least two pumps to provide continuous operation if one pump fails or requires repairs.

8.2R Each pump must be equipped with a suction and a discharge isolation valve so that the pump can be isolated from the wet well or discharge force main for draining, cleaning, repacking and other maintenance work.

8.2S Pump seal water from a domestic water supply must have an air gap to prevent contamination of the public water supply from back flows.

8.2T Some lift stations have emergency generators so they can continue to operate during power failures.

8.2U The major valves found in wastewater lift stations are:

1. Pump suction and discharge isolation valves (gate, plug, knife),
2. Discharge check valves (swing or ball check, wafer), and
3. Cross-connect or pump discharge pipe manifold isolation valves (gate, plug).

8.2V Pump suction and discharge isolation gate valves are found immediately before and after the pump to allow isolation of the pump from the wet well and the force main during pump or check valve maintenance.

8.2W Check valves are installed in the discharge of each pump to provide a positive shutoff from force main pressure when the pump is shut off and to prevent the force main from draining back into the wet well.

ANSWERS TO QUESTIONS IN LESSON 3

Answers to questions on page 64.

8.3A Operation and maintenance operators should review prints and specifications of a new lift station before construction to be sure adequate provisions have been made for the station to be easily and properly operated and maintained.

8.3B Accessibility to a lift station is important because operators and equipment need to be able to easily reach the lift station and have room to park vehicles and work.

8.3C Before equipment is installed in a lift station, determine its familiarity to agency, reliability, warranty, guarantees and the operation and maintenance aids that will be provided.

8.3D Prints and specifications should be carefully reviewed before construction and installation because changes are easily made on paper and are much more difficult in the field.

Answers to questions on page 65.

8.3E After a lift station is completed but before it is accepted, it should be inspected by the engineer, the contractor, and the operators responsible for its operation and maintenance.

8.3F Information regarding lift station equipment and performance should be filed with a copy in the lift station and a duplicate copy at the agency office.

8.3G Data from initial tests on equipment should be recorded and filed to document that the equipment meets specifications and to show how it performed when installed.

Answers to questions on page 66.

8.3H Problems that may be encountered when cleaning a wet well include slippery floors, inadequate ventilation, cleaning bar rack, disposal of debris, lack of oxygen, explosive gases, and toxic gases.

8.3I Hazards found in confined spaces include lack of oxygen, explosive and toxic gases.

8.3J Hazards encountered in sumps can be reduced by adequate hosing of sludges and slimes on sump floor and ventilation to provide a satisfactory environment.

Answers to questions on page 66.

8.3K When inspecting electrical equipment, start by recording all name plate data.

8.3L When inspecting an electrical circuit or equipment, the main circuit breaker must be locked in the *OFF* position.

8.3M Extra fuses should be kept at the station so blown fuses can be replaced immediately and equipment down time is minimized.

8.3N The working of the electrical circuits should be learned before the station becomes operational.

Answers to questions on page 68.

8.3O Anti-rotation equipment is used to prevent the pump from rotating in the wrong direction.

8.3P If a universal joint is over-lubricated, the seal on the universal will blow and cause failure in a very short time.

8.3Q If an engine's internal alarm system fails, the engine could burn up.

8.3R When changing engine oil, look for metal filings and sludge as indicators of engine condition. Look for water or an oil-water emulsion that indicates water in the wrong place.

8.3S Engines must be inspected thoroughly in an attempt to prevent problems and to learn what to do if problems develop. The jobs of troubleshooting and repairing become easy when there are good data for reference.

8.3T When lubricating the clutch throw-out bearing, lubrication should not be excessive.

8.3U Condensation can form inside an engine when a hot engine cools.

8.3V We must have oil, water and fuel for engine operation.

Answers to questions on page 70.

8.3W Leakage from a packing gland should be approximately one drop per second.

8.3X Teflon packing should not get hot because it will glaze and stop working properly.

8.3Y The minimum pressure for the flushing water on a mechanical seal is 3 to 5 psi above the pump discharge pressure.

8.3Z The first thing to do before operating a lift station is to open any valves on the influent line to fill the sump. The pump suction and discharge valves must be open before the pump is started.

8.3AA The debris left in the sump should be removed to prevent damage to the pump and clogging of pipe lines.

8.3AB Sump level can be determined by:

1. Sump level indicator,
2. Visual inspection, and
3. Action of mercury switches.

8.3AC Pump rotation can be determined by noting:

1. If rotation is in direction of arrow on side of pump,
2. If rotation is in direction of volute in centrifugal pumps,
3. Size of flow and discharge pressure, and
4. Amperage drawn by pump motor.

8.3AD Yes, all points of operation for all pumps must be inspected.

8.3AE Do not operate any unit if you think it is not functioning properly.

8.3AF All data must be recorded when test operating the station so you have a record of conditions when the station started.

ANSWERS TO QUESTIONS IN LESSON 4

Answers to questions on page 72.

8.4A Nearby streams and rivers can be protected from wastewater when a lift station fails by the use of portable emergency equipment to pump wastewater to a functioning section of the downstream collection system.

8.4B Complaints from the public about a lift station can be minimized if the operators responsible for the lift station maintain it in top operating condition and respond to complaints and questions in a positive and concerned manner. When responding to a complaint, be sure to tell the public what has been done or what will be done to correct the complaint.

8.4C The most important rule that always must be considered when visiting a lift station is *SAFETY*.

Answers to questions on page 77.

8.4D The frequency of lift station visits depends on the following:

1. Number of stations in community,
2. Type of wastewater being conveyed,
3. Potential damage from storms flooding station,
4. Condition of equipment,
5. Design of facility and equipment installed,
6. Adequacy of preventive maintenance and overhaul program,
7. Type, adequacy, and reliability of telemetry system, and
8. Attitude of operating agency towards operation and maintenance.

8.4E Lift station failures include:

1. Electrical power failures,
2. Failure of level sensing or other control equipment,
3. Flooded wet wells,
4. Plugged pump impellers or lines,
5. Overheated and tripped out motor thermals,
6. Sump pump off and sumps or dry wells flooded,
7. Air- or gas-bound pump,
8. Stuck or blocked check valve,
9. Pump control systems not functioning,
10. Failure of lift station telemetry system, and
11. Ventilation fans burned out.

8.4F The critical time for a lift station after failure is the time interval before flooding or damage occurs.

8.4G Daily visits to a lift station are required when essential operational and maintenance tasks must be performed on a daily basis to keep the station operable and reliable.

8.4H For a lift station to be visited only from once a week to once a month, the following requirements must be met:

1. Equipment lubrication reservoirs must be large enough,
2. Telemetry of the station must include wet wells, dry well sump pump pit level, power, compressor, check valves and auxiliary equipment, and
3. Crews must be able to respond to alarms before flooding or damage occurs.

Answers to questions on page 79.

8.4I There are two types of significant lift station visits:

1. To schedule routine preventive maintenance upon the equipment and the station, and
2. To respond to a lift station alarm or emergency condition to restore the station to operation.

8.4J The number of responses to lift station alarms or emergency conditions can be minimized by a good preventive maintenance program and if the frequency schedule is at the proper intervals with clear duty assignments in writing and completion verified by management.

8.4K Lift stations should have a sign-in log to reduce the number of mysterious changes in station operation such as pumps turned off, control system changes and station doors or gates left unlocked. Also this practice provides a method for reaching the appropriate person when the need arises to issue corrective instructions.

8.4L The Station Book should contain the station identification number, a map showing important facilities, station description, equipment data sheets, safety instructions, responses to emergency conditions and the station's preventive maintenance schedule.

Answers to questions on page 82.

8.4M Alarm situations may be transmitted over leased telephone lines or by a radio signal.

8.4N An emergency crew at a lift station should notify the dispatcher when they will call in again so in case a serious injury occurs and they are unable to contact the dispatcher, rescue operations can be started.

8.4O Overhead power lines should be inspected by emergency crews upon arrival at a lift station because if they are broken, they could come in contact with a chain link fence or other conductor and electrocute a crew member opening a gate.

8.4P The major categories of lift station problems are:

1. Power,
2. Control systems,
3. Pumping systems, and
4. Structures.

ANSWERS TO QUESTIONS IN LESSON 5

Answers to questions on page 85.

8.5A The two major parts of a maintenance program are:

1. Scheduling the work, and
2. Performing the work.

8.5B Equipment manufacturers' recommendations must be closely followed to maintain equipment warranties.

8.5C Maintenance requirements may be greater on new lift stations handling low flows because detention times in wet wells and force mains can be very long and allow the production of hydrogen sulfide.

8.5D Field crews can make valuable contributions because they are familiar with the station, notice changing conditions, and are capable of comparing conditions and operational characteristics.

8.5E A form showing work completed must be compared with the work assignment to be sure all scheduled work is completed.

Answers to questions on page 88.

8.6A Records should not be filed in a lift station because they can get lost or misplaced. Also they are of little value to supervisors or managers.

8.6B Lift station costs include power, fuel, operation and maintenance (labor, vehicles, equipment and supplies), scheduled preventive maintenance, unscheduled repair costs, responses to alarms and vandalism.

8.6C Activity codes are used to help identify exactly how money is spent on a lift station.

8.6D Reports should be written detailing how repairs are made so if a similar job must be done in the future, this report can serve as a helpful reference.

OBJECTIVE TEST

Chapter 8. LIFT STATIONS

Please write your name and mark the correct answers on the answer sheet as directed at the end of Chapter 1. There may be more than one correct answer to each question.

TRUE-FALSE

1. Reliability is the most important requirement for a lift station.
   1. True
   2. False
2. Sump pumps are located in wet wells.
   1. True
   2. False
3. The size of the wet well is important to the pumping system operation.
   1. True
   2. False
4. The same pump should always start first in a lift station with two pumps.
   1. True
   2. False
5. Pump isolation valves should be gate valves.
   1. True
   2. False

MULTIPLE CHOICE

6. Pumps should not be allowed to start and stop frequently in lift stations because frequent motor starts
   1. Cause excessive wear on control circuit relays.
   2. Cause excessive wear on motors.
   3. Cause overheating.
   4. Consume more energy than a motor that operates continuously.
   5. Keep solids suspended in a wet well.
7. If a wet well is too large, problems may develop due to
   1. Production of hydrogen sulfide.
   2. Production of odors.
   3. Pumps starting and stopping too frequently.
   4. Solids settling out.
   5. Wastewater turning aerobic.

8. Flow may be expressed in which of the following units of measurement?
   1. AC-FT
   2. CFS
   3. GPM
   4. MGD
   5. MG/L

9. Important lift station considerations include
   1. Access.
   2. Costs.
   3. Pumps.
   4. Reliability.
   5. Safety.

10. Cost records for a lift station should include costs of
    1. Living.
    2. Maintenance.
    3. Operation.
    4. Power.
    5. Repairs.

11. Lift stations are used to lift
    1. Sewer gases.
    2. Sewer odors.
    3. Sewer pipe.
    4. Storm water.
    5. Wastewater.

12. Lift station location depends on
    1. Depth of excavation.
    2. Diameter of sewer.
    3. Economic factors.
    4. Level of groundwater table.
    5. Pipe material.

13. Items that should be examined when READING lift station SPECIFICATIONS include
    1. Access.
    2. Equipment reliability.
    3. Layout.
    4. Proper color coding on pipes.
    5. Warranties.

14. Common types of lift station failures include
    1. Controls.
    2. Foundation.
    3. Power.
    4. Pumps.
    5. Structural or building.

15. Written reports providing details of unusual conditions or repairs to a lift station should include
    1. Additional maintenance scheduling required.
    2. Good literary style.
    3. How repairs were made.
    4. Review of literature.
    5. Special equipment required.

16. Pumps draw more power starting than during normal operating conditions because
    1. Energy is required to get the water moving.
    2. Gate valves have to be pushed open.
    3. Pipe friction losses are greater.
    4. The motor and pump have to start turning.
    5. The total dynamic head is greater.

17. What items should be inspected when responding to a station alarm at night?
    1. Dry well
    2. Interior lighting
    3. Motor control center and power panel
    4. Operation of ventilation equipment
    5. Wet well

18. A lift station Station Book should include
    1. Agency budget.
    2. Equipment data sheets.
    3. Map showing important facilities.
    4. Responses to emergency conditions.
    5. Safety instructions.

19. When preparing a lift station maintenance program, which of the following factors should be considered?
    1. Computer activity codes
    2. Knowledge gained from experience
    3. Recommendations of equipment manufacturers
    4. Requirements of lift station
    5. Station identification number

20. The purpose of a lift station sign-in log is to
    1. Allow guests to sign their names.
    2. Find out who may need corrective instructions.
    3. Identify who makes changes in station operation.
    4. Keep track of who visits the lift station.
    5. Produce a higher reliability factor in operator performance.

21. Items that should be considered when determining the frequency of visits to lift stations include
    1. Adequacy of preventive maintenance and overhaul program.
    2. Design of facility.
    3. Number of stations in the community.
    4. Type, adequacy, and reliability of telemetry system.
    5. Type of wastewater.

22. Which of the following items should be inspected when a new lift station is put into operation?
    1. Corrosion damage
    2. Debris in wet well
    3. Manpower requirements
    4. Valve positions (open or closed)
    5. Wet well level controllers

23. Which of the following items should be inspected on new pumps?
    1. Cavitation
    2. Direction of rotation
    3. Drive mechanism
    4. Guards on rotating parts
    5. Packing gland or mechanical seal

24. After a lift station has been completed, but before it is put in service, which of the following items should be inspected?
    1. Access for equipment removal
    2. How to remove grit and debris from wet well
    3. Location of electrical lines
    4. Maintenance and overhaul costs
    5. Operating costs

25. Items that should be examined when *REVIEWING* lift station *PRINTS* include
    1. Accessibility.
    2. Layout of pipes and equipment.
    3. Lighting.
    4. Overhead clearances.
    5. Warranties.

26. Bar racks are undesirable in sanitary wastewater collection systems because
    1. Disposal of the screenings is a problem.
    2. The screenings cause odors and attract flies.
    3. The screenings must be removed.
    4. They stop solids from plugging pumps.
    5. Wrong, they are desirable.

27. Limitations of electrode controllers include
    1. Grease or slime can cover electrodes.
    2. If not properly maintained, pumps may not start and stop when desired.
    3. Rags and debris can foul electrodes.
    4. Reliable operation.
    5. Safe to use.

28. Lift stations may be visited at time intervals from once a week to once a month if
    1. The bar screen keeps plugging with grease.
    2. The community has only one lift station.
    3. The equipment lubrication reservoirs are large enough.
    4. The station has an adequate telemetry system.
    5. You are lucky. This idea won't work, lift stations must be visited daily.

29. Significant types of lift station visits include
    1. Giving guided tours.
    2. Mowing the lawn.
    3. Performing scheduled routine preventive maintenance.
    4. Responding to lift station alarm.
    5. Supervisors checking to be sure crews are performing assigned duties.

30. After correcting an alarm situation in a lift station and before leaving the station, which of the following tasks should be done or checked?
    1. Contact dispatcher to be sure alarm condition is cleared from telemetry alarm panel.
    2. Observe wet well and inflow.
    3. Record problem and correction in station book.
    4. Secure lift station.
    5. Turn ventilation system off.

31. How can a supervisor be sure scheduled maintenance is completed?
    1. Ask the operators.
    2. Hire someone to inspect completed work.
    3. Inspect work performed.
    4. Use a form that compares work assigned with work completed.
    5. Wait and see if there are any failures.

32. Lift station pumps should
    1. Always be submersible pumps.
    2. Be capable of pumping spheres at least 2.5 inches in diameter.
    3. Have a bottom volute drain.
    4. Have an air gap in the seal water piping if the water comes from a domestic water supply.
    5. Have suction and discharge isolation valves.

33. Limitations of float control systems include
    1. Float attachment line can break and call for all or none of the pumps to operate.
    2. Floats develop leaks.
    3. Grease and debris can enter the stilling well and hinder or stop the movement of the float.
    4. Sensitivity to fluctuations of water surface elevation in wet well.
    5. Signals activated by floats are easily transmitted to pumps.

34. Daily visits to lift stations may be undesirable because they
    1. Allow equipment to be maintained every day.
    2. Provide operators the opportunity to inspect the equipment every day.
    3. Minimize problems.
    4. Sometimes provide a situation where important maintenance work is postponed until tomorrow.
    5. Tend to cause operators to be less critical than less frequent visits.

35. Complaints regarding lift stations can be minimized by
    1. Analyzing causes of complaints and taking corrective action.
    2. By-passing the station.
    3. Good landscaping and maintaining pleasant appearance.
    4. Proper maintenance.
    5. Responding to citizen's complaints or questions in a positive and concerned manner.

REVIEW QUESTIONS

36. Precautions that should be taken when operating a high velocity cleaner include
    1. Being careful not to "blow toilets."
    2. Being careful not to cause more damage if a sewer appears to be failing.
    3. Not allowing so much material to build up below the nozzle that it becomes stuck.
    4. Not letting the nozzle rotate in one place.
    5. Not using a porcupine nozzle.

37. Hydrogen sulfide must be controlled because the gas is
    1. Colorless.
    2. Explosive.
    3. Flammable.
    4. Odorless.
    5. Toxic.

End of Objective Test

SUPPLEMENT TO CHAPTER 8

LIFT STATIONS

A PREVENTIVE MAINTENANCE PROGRAM

FOR

PARK ROAD LIFT STATION

NOTE: For another type of operation and maintenance (O&M) manual for a typical lift station, see "Standard Operating Job Procedures (SOJP) No. 3, Pump Stations" from "A Guide for the Development of Standard Operating Job Procedures for Wastewater Treatment Plant Unit Operations," developed by Charles County Community College, La Plata, Maryland, for the Manpower Development Staff, U.S. Environmental Protection Agency, Washington, D.C. 20460, 1973.

EXPLANATION OF SUPPLEMENT

This supplement is intended to serve only as an example of a portion of a typical lift station book. The actual station book for a typical lift station (S-14) consists of two, three-inch thick binders which contain equipment and agency data that are described in this chapter. Material contained in this supplement (starting on page 413) is from Sacramento County's maintenance and overhaul manual. The manual was developed and written by the County and serves 128 separate facilities.

The actual maintenance and overhaul manual contains several hundred pages and prescribes maintenance procedures for equipment in 128 facilities ranging from wastewater lift stations, storm water lift stations, wastewater treatment lift stations, wastewater treatment plants, and domestic water wells and distribution systems. The entire maintenance and overhaul manual is not presented. Only portions that pertain to some of the equipment listed in the typical station (S-14) are presented to illustrate a method used by one agency to accomplish its maintenance program.

The mechanical maintenance field crews that use the maintenance and overhaul manual are skilled operators who perform all work with the exceptions of electrical power services and instrumentation that consists of analog or digital components. This work is performed by other operators qualified with the necessary skills in the electrical and instrumentation fields.

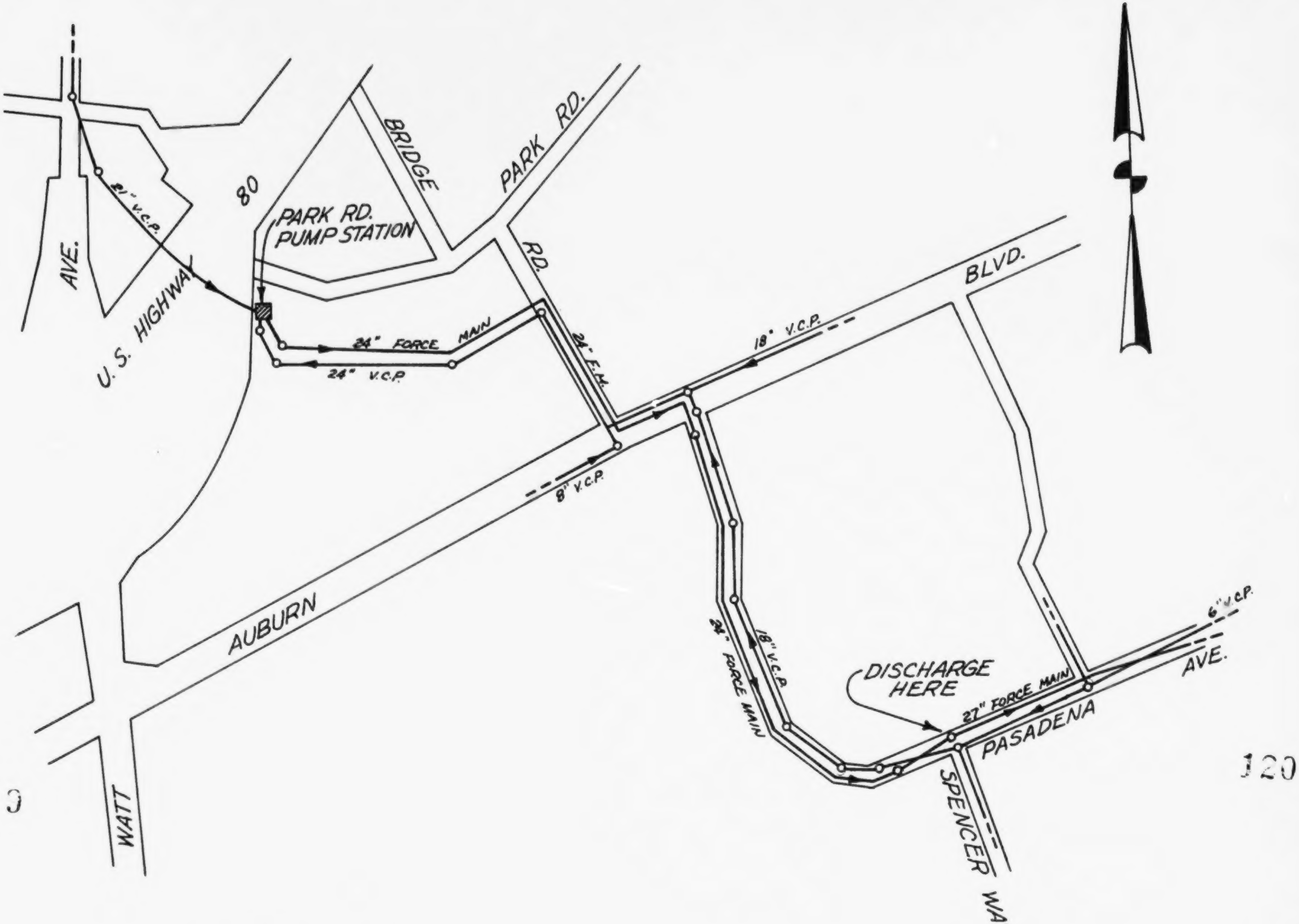
TABLE OF CONTENTS

GENERAL DESCRIPTION	PAGE NO.
EMERGENCY CONDITIONS	100
PREVENTIVE MAINTENANCE SCHEDULE	101
MISCELLANEOUS EQUIPMENT	100
SAFETY INSTRUCTIONS	100
STATION DESCRIPTION	100
STATION AND FORCE MAIN LOCATION	99

SCHEDULED PREVENTIVE MAINTENANCE — S14

EQUIPMENT	MANUAL REFERENCE	DRAWING	PAGE NO.
AIR COMPRESSOR	1.10	1.10-G	104
Condition Check	1.10-A		105
Oil Change	1.10-B		105
Small Compressor Lube	1.10-F-1		105
Drain Condensation	1.10-F-3		105
Air Filter	1.10-H-2-4		105
Safety Valve	1.10-I		105
Gage Check	1.10-J		105
BELT	2.02		105
V Belt Check-Adjust	2.02-B		105
BLOWERS-VENTILATION	2.20		105
Removal From Service	2.20		105
Inspection	2.20-A		105
BUILDING MAINTENANCE	2.40		106
Locks	2.40-A		106
Lights	2.40-B		106
Doors	2.40-C		106
Housekeeping	2.40		106
Electrical Prev.-Maintenance	2.40		106
CHLORINATOR	3.20		106
Isolation	3.20-A-1		106
Pressure Reducing Valve	3.20-A-7		106
Check For Leaks	3.20-A-9		106
Valve Check	3.20-A-11		106
Cleaning Chlorinator Body	3.20-A-15		106
Cleaning Valve Seat & Valve Plug	3.20-A-16	3.20-P-Q	106
Cleaning Primary & Secondary Filter	3.20-A-17	3.20-R	107
Meter Tube Cleaning	3.20-A-18	3.20-S	108
CONTROLS-ROTAMETER	3.31	3.31-A	109
Bubble Line Check	3.31-D		109
Manual Purge	3.31-D-1		109
COUPLING	3.40	3.40-C	110
General	3.40-A		110
Check Flexible Coupling	3.40-B		110
Coupling Disassembly	3.40-B-1-2		110
Alignment Procedure	3.40-B-3		110
DEHUMIDIFIER	3.50		111
Operational Check	3.50-A		111
Lube And Inspection	3.50-B		111
ELECTRIC MOTORS	6.01	6.01-B-C	111
Condition Check	6.01-A		111
Unusual Conditions	6.01-B		111
Lube-Flush Bearings	6.01-C		111
Scope Bearings	6.01-F		111
METERS	6.10		111
Gallons Counter	6.10-J		111
Electrical Power Meter	6.10-K		111
PIT-WET	7.10		114
Inspection	7.10		114
Definition Of Wet Pit	(footnote)		114

PUMPS-CENTRIFUGAL	7.20	7.20-A	114
General	7.20		114
Packing Glands	7.20-A-B		114
Condition Check	7.20-E-1		114
Operate Pumps Alternately	7.20-G		116
Lubrication	7.20-H-1		116
Water Lube Line	7.20-N		116
Pumping Range	7.20-P		116
PUMPS SUMP	7.20	7.20-C	116
Operation Check	7.20-L-1		116
Inspection	7.20-L-2		116
STRAINERS	7.94		118
Inspection And Cleaning	7.94-A		118
VALVES-AIR RELIEF	8.10		118
VALVES-GATE	8.30	8.30-A	118
Operation	8.30-A		118
Packing Adjustment	8.30-B		118
Packing Lube	8.30-C		118
VALVES-BALL	8.30		118
Operation Check	8.30-D-1		118
Inspect-Clean	8.30-D-2		118
VALVES-GLOBE	8.30-E		118
VALVES-BURIED	8.30		118
Inspect-Lubricator	8.30-F		118
Hydraulic Gate Operator	8.40-C		118
WATER WELLS	9.01		118
Clean-Inspect-Tank	9.01-A		118
Tank Maintenance	9.01-B		119
Standing Water Level	9.01-C-1		119
Sounding Well	9.01-C-2		119


21" V.C.P.
AVE.
U.S. HIGHWAY
80
PARK RD.
PUMP STATION
BRIDGE
PARK RD.
RD.
BLVD.
24" FORCE MAIN
24" V.C.P.
24" F.M.
18" V.C.P.
8" V.C.P.
AUBURN
WATT
24" FORCE MAIN
18" V.C.P.
DISCHARGE
HERE
27" FORCE MAIN
6" V.C.P.
PASADENA
AVE.
SPENCER
WAY
110
120

GENERAL DESCRIPTION

1. *STATION DESCRIPTION*

The design of the Park Road Wastewater Lift Station S-14 includes the following features:

a. A dual centrifugal pump lift system discharging into a common force main.

b. An automatic ampl-speed flow match control system.

c. A chlorine injection system into the discharge flow.

d. A telemeter monitoring system which telemeters to the central office.

2. *SAFETY INSTRUCTIONS*

a. The station uses 115/440 volt electricity in various applications. Use caution when near wires or connection.

b. Use adopted safety measures when in areas or working on equipment containing chlorine.

c. Air pressure lines within the station contain pressures up to 60 PSI. Care should be taken to isolate any air-operated component before removing it from the system.

d. Working in an enclosed area presents safety hazards to personnel (wet pit). Unless there is a way of constantly testing the station atmosphere, a ventilation blower must operate at all times while the wet pit is occupied. If the main ventilation blower is out of service and work must be performed in an enclosed area, a blower of equivalent capacity must be placed in operation during occupancy of the station. An *ENCLOSED AREA* is defined by the State of California, Division of Industrial Safety as: The interior of storm drains, sewers, vaults, utility pipe lines, manholes, and any other structure which is similarly surrounded by confining surfaces so as to permit the accumulation of dangerous gases or vapors.

e. Return all equipment to normal operating condition before leaving the station. Verify that the station lights have been turned off and the door is locked.

f. In the event of station flooding, three operators must be present during maintenance, one in the pit and two above flooded area.

A safety harness and safety line, and at least one explosion-proof light must be available during the performance of enclosed area maintenance.

3. *EMERGENCY CONDITIONS*

The Park Road Lift Station S-14 will be put out of operation under the following conditions:

a. Power failure,

b. Inlet line stoppage,

c. Simultaneous pump system failure, and

d. Station flooding dry pit area.

In the event of an emergency condition whereby the station becomes inoperative due to power failure, an auxiliary generator can be substituted for normal power. This generator must have a minimum capacity output of 400 volts - 135 K.W. to operate one wastewater lift pump and small power demands for station operation.

The isolation of the station from normal power source to operation on emergency generator conditions shall be performed by an electrician.

In the improbable situation the station would have to be bypassed, the following procedure would be used, using an auxiliary pump: The suction line must be placed in manhole 1 and the pump discharge line placed in manhole 2 at the intersection of Pasadena Ave. and Spencer Way, approximately 3,550 ft., i.e. a little under ¾ of a mile. For these locations, refer to the drawings on page 415.

In order to satisfy the flow demand, it will be necessary to use a 10" discharge line. (Pump (10" Jaeger) and hose available at maintenance yard).

MISCELLANEOUS EQUIPMENT - S14

Wastewater Pumps

PACKING ⅜" WATER LUBE

LUBE LINE

⅜" line, solenoid, press gage, ¼" Foxboro purge meter model NA 1501A scale 1-5 c.p.m. check and gate valve. Strainer screen in main line.

DRAIN LINE - ¾"

COUPLING - WEEDS SUR. FLEX #14F

SUCTION - 12" LINE

Gate valve - 12" Crane - non rising stem, wheel control.

DISCHARGE 10" LINE

Ball valve automatic stop and check control. Bottom coupling - 1026DV2815-10" top coupling 101131. Willamette emergency shut off control size 10. Emergency close switch A540031B. Micro adj. pulse switch #1PD1-2-64 serial 2. 2 mercoid control switches on ¾" pipes. Leslie strainer.

CONTROL BUBBLE LINE, AIR COMP.

Alternation-lead pump manual.

PANEL

Wet well level
Hour counters (2)
Fold Chart GPM & PSI.
Pump motor control switches (2)
Pump motor tachometers (2)

FORCE MAIN

14" line in the station. Foxboro pressure. Transmitter Model 144B.P. Foxboro filter Regulator type 65-R. Magnetic flowmeter on 14" discharge line.

GATE VALVE #1

Location across the creek in the rear of the station. Raised manhole cement box outside of manhole with buried valve stem, wrench in the station.

GATE VALVE #2

Location on the southeast side of Pasadena Ave. at Auburn Blvd., intersection large manhole cover, small valve stem cover nearby. Wrench in station.

SLIDE GATE

Influent, power failure automatic, manual hydraulic water power norpack compression cylinder, model XDCSS ¾" water lines, valves, solenoids and Leslie strainer.

TELEMETER

Pit high water.
Lower floor sump pump failure.
Low water pressure.
Influent gate.
Panel door.
Low chlorine pressure.

Motor by-pass pin outs to relieve alarm signal during intentional motor power shutoff for mechanical repair.

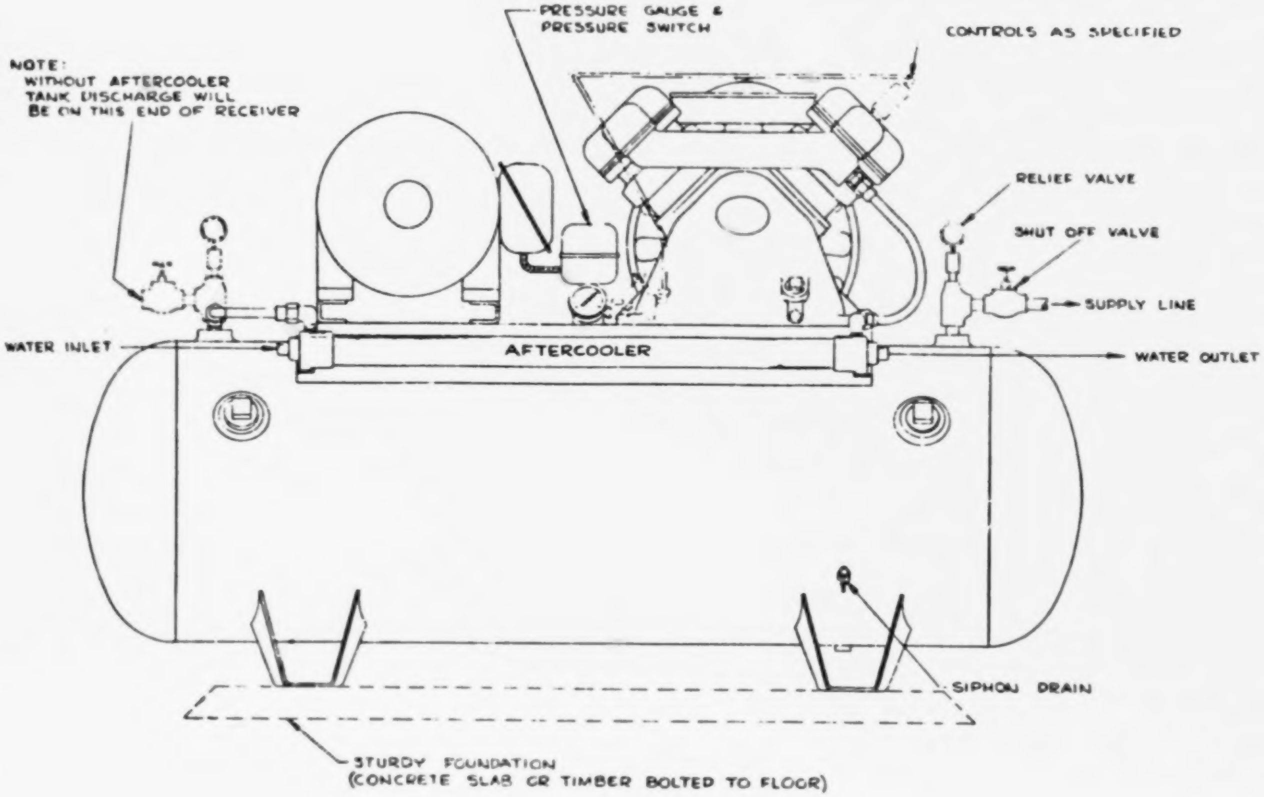
PREVENTIVE MAINTENANCE SCHEDULE — S-14

EQUIPMENT	TASK DESCRIPTION	FREQUENCY*	ISOLATION REQUIRED	MAINT./OVERHAUL INST. NO.	PAGE NO.
AIR COMPRESSOR	LUBRIFLUSH MOTOR	A	YES	6.01-C	111
AIR COMPRESSOR	SCOPE MOTOR BEARINGS	A	NO	6.01-F	111
AIR COMPRESSOR	SCOPE COMP. BEARINGS	A	NO	6.01-F	111
AIR COMPRESSOR	CHECK BELTS	S/A	YES	2.02-B	105
AIR COMPRESSOR	CHECK GAGES	S/A	NO	1.10-J	105
AIR COMPRESSOR	CHECK RELIEF VALVE	S/A	NO	1.10-I	105
AIR COMPRESSOR	CLEAN AIR FILTER	S/A	YES	1.10-H-2	105
AIR COMPRESSOR	CHECK MOTOR	M	NO	6.01-A-B	111
AIR COMPRESSOR	CHECK COMPRESSOR	M	NO	1.10	105
AIR COMPRESSOR	CHANGE LUBE OIL	M	YES	1.10-B-2	105
AIR COMPRESSOR	BLEED TANK	M	YES	1.10-F-3	105
AIR COMPRESSOR SMALL	LUBE COMPRESSOR	S/A	YES	1.10-F-1	105
AIR COMPRESSOR SMALL	DRAIN CONDENSATION	M	YES	1.10-F-3	105
VENT BLOWERS (2)	CHECK MOTOR LUBE	A	YES	2.20-A-4-5	105
VENT BLOWERS (2)	CHECK OPERATION	M	NO	2.20-A	105
BUILDING MAINTENANCE	CHECK LOCKS	M	NO	2.40-A	106
BUILDING MAINTENANCE	CHECK LIGHTS	M	NO	2.40-C	106
BUILDING MAINTENANCE	CHECK DOORS	M	NO	2.40-D-1	106
CHLORINATOR	CLEAN VALVE SEAT & PLUG	M	YES	3.20-A-16	106
CHLORINATOR	CLEAN PRIMARY AND SECONDARY FILTER	M	YES	3.20-A-17	107

* A — Annually; S/A — Semi-Annually; M — Monthly.

EQUIPMENT	TASK DESCRIPTION	FREQUENCY	ISOLATION REQUIRED	MAINT./OVERHAUL INST. NO.	PAGE NO.
CHLORINATOR	SHUT DOWN CHLORINATOR	M	YES	3.20-A-1	106
CHLORINATOR	CLEAN METER TUBE	M	YES	3.20-A-18	108
CHLORINATOR	CHECK C.P.R. VALVE	M	YES	3.20-A-7	106
CHLORINATOR	CHECK FOR LEAKS	M	NO	3.20-A-9	106
CHLORINATOR	BODY CLEANING	M	NO	3.20-A-15	106
CHLORINATOR	CHECK VALVES	M	NO	3.20-A-11	106
CONTROL ROTAMETER	CHECK BUBBLE LINE	M	NO	3.31-D	109
DEHUMIDIFIERS (2)	INSPECT LUBE UNIT	A	YES	3.50-B	111
DEHUMIDIFIERS (2)	CHECK OPERATION	M	NO	3.50-A	111
PIT WET	CLEAN PIT	A	NO	7.10-A-1	114
WASTEWATER NO 1 PUMP	LUBRIFLUSH MOTOR	A	YES	6.01-C	111
WASTEWATER NO 1 PUMP	SCOPE MOTOR BEARINGS	A	YES	6.01-F	111
WASTEWATER NO 1 PUMP	SCOPE PUMP BEARINGS	A	NO	6.01-F	111
WASTEWATER NO 1 PUMP	LUBE PUMP BEARINGS	S/A	NO	7.20-H	116
WASTEWATER NO 1 PUMP	CHECK WATER LUBE LINE	S/A	NO	7.20-N-2	116
WASTEWATER NO 1 PUMP	CHECK COUPLING	S/A	YES	3.40-B	110
WASTEWATER NO 1 PUMP	CHECK BALL VALVE	S/A	YES	8.30-D	118
WASTEWATER NO 1 PUMP	CHECK STRAINER SCREEN	S/A	YES	7.94-A	118
WASTEWATER NO 1 PUMP	CHECK MOTOR	M	NO	6.01-A-B	111
WASTEWATER NO 1 PUMP	CHECK PUMP	M	NO	7.20-E	114
WASTEWATER NO 1 PUMP	CHECK PACKING	M	NO	7.20-A	114
WASTEWATER NO 1 PUMP	CHECK DRAIN LINE	M	NO	7.20-E-1	114
WASTEWATER NO 2 PUMP	LUBRIFLUSH MOTOR	A	YES	6.01-C	111
WASTEWATER NO 2 PUMP	SCOPE MOTOR BEARINGS	A	NO	6.01-F	111
WASTEWATER NO 2 PUMP	SCOPE PUMP BEARINGS	A	NO	6.01-F	111
WASTEWATER NO 2 PUMP	LUBE PUMP BEARINGS	S/A	NO	7.20-H	116
WASTEWATER NO 2 PUMP	CHECK WATER LUBE LINE	S/A	NO	7.20-N	116
WASTEWATER NO 2 PUMP	CHECK COUPLING	S/A	YES	3.40-B	110
WASTEWATER NO 2 PUMP	CHECK BALL VALVE	S/A	YES	8.30-D	118

EQUIPMENT	TASK DESCRIPTION	FREQUENCY*	ISOLATION REQUIRED	MAINT./OVERHAUL INST. NO.	PAGE NO.
WASTEWATER NO 2 PUMP	CHECK STRAINER SCREEN	S/A	YES	7.94-A	118
WASTEWATER NO 2 PUMP	CHECK MOTOR	M	NO	6.01-A-B	111
WASTEWATER NO 2 PUMP	CHECK PUMP	M	NO	7.20-E	114
WASTEWATER NO 2 PUMP	CHECK PACKING	M	NO	7.20-A	114
WASTEWATER NO 2 PUMP	CHECK DRAIN LINE	M	NO	7.20-E-1	114
SUMP PUMP	INSPECT SUMP PUMP	S/A	YES	7.20-L-2	116
SUMP PUMP	CHECK OPERATION	M	NO	7.20-L-1	116
MAIN WATER STRAINER	CLEAN STRAINER	A	YES	7.94-A	118
GATE VALVES (2)	REPAIR GATE VALVES (2)	A	YES	8.30-A	118
FORCE MAIN BURIED VALVES (2)	OPERATE LUBE-VALVES	A	NO	8.30-F	118
SLIDE GATE	EXERCISE SLIDE GATE	A	NO	8.40-C	118
WATER WELL	CHECK TANK	S/A	YES	9.01-B	119
WATER WELL	CHECK AIR RELIEF VALVES	S/A	NO	8.10-C-4	118
WATER WELL	CHECK TANK	M	NO	9.01-B	119
WATER WELL	CHECK PUMPING RANGE	M	NO	7.20-P	116
WATER WELL	SOUND WELL	M	YES	9.01-C-1-2	119
REGULATOR FILTERS (2)	CLEAN FILTERS	S/A	YES	1.10-H	105
REGULATOR FILTERS (2)	CLEAN FILTERS	M	YES	1.10-H-3	105
STA-DRY FILTERS (2)	BLEED FILTERS	S/A	YES	1.10-H-4	105
STA-DRY FILTERS	BLEED FILTERS	M	NO	1.10-H-4	105
WASTEWATER PUMP CONTROLS	ALTERNATE PUMPS	M	NO	7.20-G-1	116
WASTEWATER PUMPS	CHECK PUMPING RANGE	M	NO	7.20-P	116
WASTEWATER PUMPS	RECORD HOURS-GALLONS	M	NO	6.10-J	111
STATION POWER SUPPLY	RECORD ELECTRIC METER	M	NO	6.10-K	111
HOUSEKEEPING	CLEAN MOTORS	M	NO	2.40	106
HOUSEKEEPING	CLEAN PUMP UNITS	M	NO	2.40	106
HOUSEKEEPING	CLEAN STA. INTERIOR	M	NO	2.40	106
HOUSEKEEPING	CLEAN YARD-DRIVEWAY	M	NO	2.40	106


PRESSURE GAUGE & PRESSURE SWITCH
CONTROLS AS SPECIFIED
NOTE: WITHOUT AFTERCOOLER TANK DISCHARGE WILL BE ON THIS END OF RECEIVER
RELIEF VALVE
SHUT OFF VALVE
SUPPLY LINE
WATER INLET
AFTERCOOLER
WATER OUTLET
SIPHON DRAIN
STURDY FOUNDATION (CONCRETE SLAB OR TIMBER BOLTED TO FLOOR)

Pressure Tank Compressor
Drawing No. 1 10-G

PREVENTIVE MAINTENANCE ON AIR COMPRESSOR INCLUDES THE FOLLOWING:

A. Keep unit clean.

B. Check oil level in crankcase, add if needed

C. Drain condensate from receiver

D. Test safety valves

E. Clean suction air filter

F. Scheduled crankcase oil change

G. Check condition and tension of belts

H. Check all screws and nuts for tightness

AIR COMPRESSOR — 1.10
ISOLATION INSTRUCTION

A. PREREQUISITES:

Prior to the electrical isolation of an air compressor, ensure that the air compressor is operating normally.

B. ELECTRICAL ISOLATION:

Place the compressor motor power supply switch in the off position, lock in off position, and tag with a "Do Not Turn On" card to prevent unit operation.

C. MECHANICAL ISOLATION:

Close the air compressor discharge valve.

D. RESTORATION:

Mechanical Restoration: Open the air compressor discharge valve.

E. ELECTRICAL RESTORATION:

Unlock or untag the power switch and place in the on position.

F. OPERABILITY DEMONSTRATION:

Demonstrate the air compressor is operable by starting the air compressor and observing its operation through one complete cycle. If any portion of this system was opened, inspect that portion for leakage, i.e., oil, air, or water.

AIR COMPRESSOR — 1.10
MAINTENANCE INSTRUCTIONS

1.10A *CONDITION CHECK*

If compressor shows evidence of overheating or excessive noise, stop immediately until repairs are made. A compressor will run hot if running continuously. Check for vibrations. Keep compressor free from dirt and dust. Check for leaks of oil or grease.

1.10B 2 *OIL CHANGE*

1. Check crank case oil by turning compressor motor switch to off position and locking out if possible. Remove filler plug, oil should be at the level of the filler opening or never below the low mark on the dip stick if so equipped.
2. To change crank case oil in a compressor, turn motor switch to off position, lock out if possible. Remove both drain and filler plugs. Drain out old oil thoroughly, replace drain plug and fill crank case with new oil to the proper line. See paragraph B-1. Replace fill plug. Run the compressor 3 or 4 minutes. Shut it off and allow the oil to settle. Recheck, adding more oil if necessary.

1.10F 1 *SMALL COMPRESSOR LUBRICATION*

Small compressor bearing lube can be either oil cups or grease fittings. If equipped with oil cups, five or six drops of oil are enough. If equipped with grease fittings, lube very sparingly.

1.10F 3 *DRAIN CONDENSATION*

Drain condensation from the tank through the drain valve at the bottom.

1.10H 2 *AIR FILTER*

Air cleaners with felt pads and screens — remove cover, wipe out interior, wipe the oil impregnated pad with a solvent-dampened rag. Add three or four drops of oil to the felt. Clean the wire screen with solvent and dry thoroughly.

1.10H 4 *STA-DRY FILTERS*

Bleed sta-dry filters periodically by slowly opening, in turn, all drain cocks on filters or the air line.

1.10I *SAFETY VALVE*

When a compressor is controlled by a pressure switch for a high and low limit, a safety valve is installed. To test the safety valve, lift the lever allowing air to escape; this will insure the valve is operating.

1.10J *GAGE CHECK*

Check pressure gage for correct pressure of this particular line or unit. If you have reason to believe the pressure gage is not accurate or the demand of the pressure switch does not coincide with pressure gage and you want to check which is at fault, replace with a pressure gage known to be accurate. If the pressure gage is combined with a dampener, remove, disassemble and clean. On the pulsation-type dampener for air, set the pin in hole 5.

BELTS — 2.02

2.02B *BELT CHECK*

1. Check tension and wear. Rubber wearings near the drive are signs of improper tension, incorrect alignment or damaged sheaves. If tightening a belt does not correct slipping, check for overload, oil on the belt or other possible causes. Never use belt dressing to stop a V-belt slipping.
2. When belts need replacing, never replace one V-belt on a multiple-belt drive. Replace the complete set with a set of matching belts.

VENTILATION BLOWER — 2.20
MAINTENANCE INSTRUCTIONS

PREREQUISITE

Removal of the ventilation blower from service requires the substitution of an equivalent ventilation blower to maintain adequate ventilation inside Station S-14 while the main blower is out of service. Observe all pertinent safety practices when performing maintenance under this condition.

2.20A *INSPECTION*

1. Open the ventilation blower circuit at the wall panel.
2. Disassemble the unit and check the frame, cover, and damper for rust or corrosion. Clean with solvent. Paint if needed.
3. Check that the vibration damper and springs are operating freely.

4. If the motor is equipped with sealed bearings, no lubrication is required.
5. If the motor bearing housing is equipped with plugs, remove and check if lubricant is grease or oil. Lubricate accordingly. (If grease refer to Par. 6.01C 2-7).
6. Check for worn or frayed electrical wires. When reassembled, close the blower circuit at the wall panel and test for operation and vibration.

ISOLATION

Turn the ventilation blower power switch in control panel to the off position. If possible, lock in the off position to prevent accidental power supply to unit.

BUILDING MAINTENANCE AND INSPECTION — 2.40

A. *LOCKS*

Oil locks with a light oil, preferably a spray oil. Make sure all electrical panel locks, padlocks, and door locks work freely. Replace all defective locks.

B. *LIGHTS*

Check for broken or burned out light fixtures. Replace burned out or broken bulbs. Report broken or damaged switches.

C. *DOORS*

Check hinges, catches, and seals on all doors. Check that they swing freely and close tightly.

HOUSEKEEPING

A. Equipment and wall surface cleaning can best be done with a rag moistened with a cleaning solution. Avoid contact with electric terminals. If this is not possible, isolate the system according to the applicable isolation instructions before cleaning. Floors must be mopped with a cleaning solution.

B. Gather the accumulated debris from the exterior yard area and place it in a waste container carried in the service vehicle.

ELECTRICAL PREVENTIVE MAINTENANCE

Isolate all circuits prior to performing maintenance according to the applicable isolation instruction. Inspect electric connectors for looseness and insulation cracking. Tighten and repair when necessary. Do not attempt to maintain or work on live circuits.

CHLORINATOR — 3.20-A MAINTENANCE INSTRUCTIONS

3.20A 1 *ISOLATION*

Turn off chlorine supply; close tank valve, close containment valve. Turn off injector water supply. (Be sure all chlorine is exhausted from unit before turning off water.)

3.20A 7 PRESSURE-REDUCING VALVE

Remove protecting cap nut, remove cap, remove silver lock nuts (2), remove needle assembly, clean seat assembly. Reassemble new gasket as needed.

3.20A 9 *CHECK FOR CHLORINE LEAKS*

Use ammonia and check all chlorine connections for leaks. (If white smoke appears, leak present.)

3.20A 11 *CHECK VALVES*

Check valves for leaks around stems and for damaged threads. Check flex lines for kinks and/or signs of corrosion. Replace if needed.

3.20 15 *CLEANING CHLORINATOR BODY*

Use a damp cloth, then wipe dry. Apply a small amount of polishing wax and wipe with dry cloth.

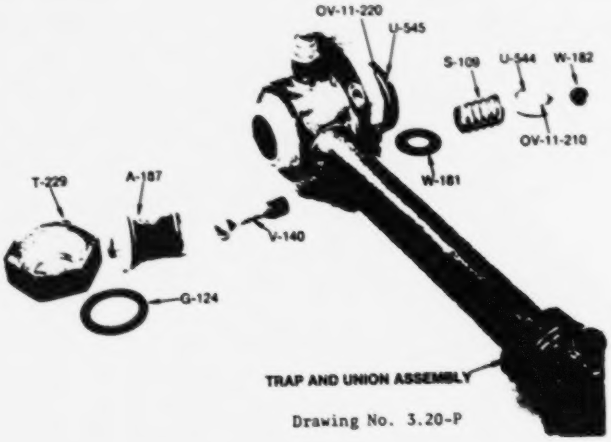
3.20A 16 *CLEANING VALVE SEAT AND VALVE PLUG*

See Drawings Nos. 3.20-P and 3.20-Q.

To disassemble capsule, remove large hexagonal nut (T-229) on back of capsule and remove the secondary inlet filter assembly (A-187). Insert small screw driver into the inlet to hold the inlet valve plug (V-140) against valve seat, unscrew the vent screw (W-182), the valve plug, spring retainer, spring and vent plug may now be removed. Unscrew the adaptor seal plug (U-545) and remove the valve seat (U-543).

Drawing No. 3.20-P

Drawing No. 3.20-Q



Drawing No. 3.20-P

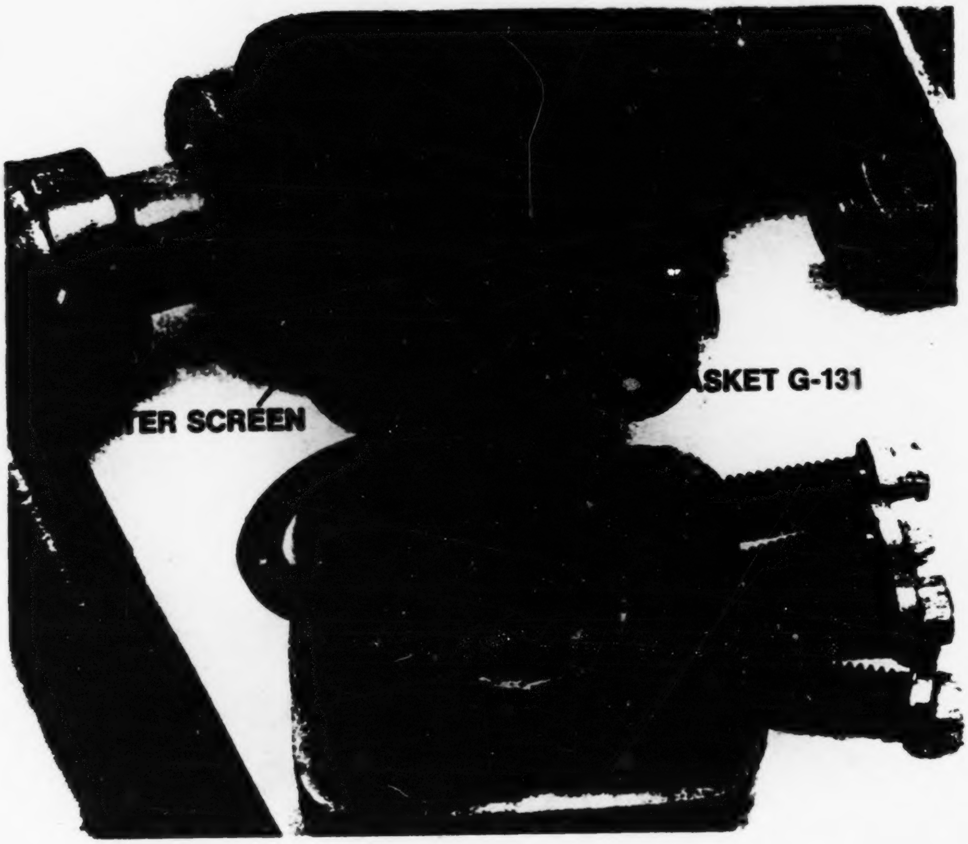
VALVE SEAT
U-543

CHLORINATOR — 3.20A
MAINTENANCE INSTRUCTIONS (cont'd)

3.20A 17 *CLEANING PRIMARY FILTER*

Remove the four (4) bolts holding the filter cover on and remove the cover and screen from body. Clean the screen by submerging in hot water with a detergent and remove dirt with a coarse bristle brush. Dry thoroughly.

Secondary filter (A-187). Clean in the same manner.

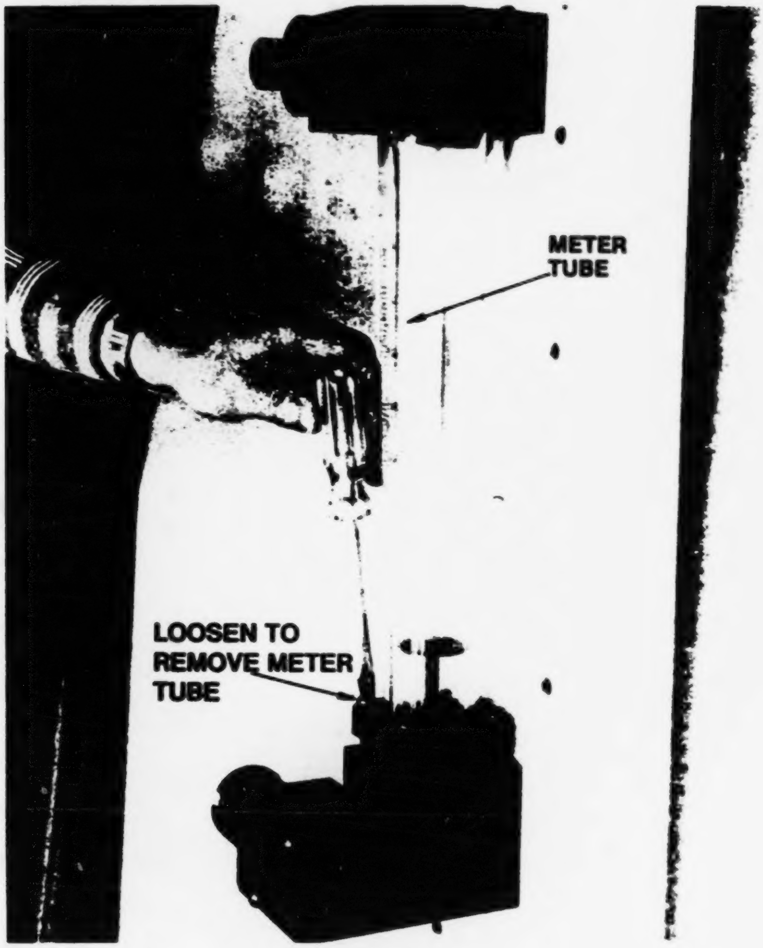


Drawing No. 320-R

CHLORINATOR — 3.20A
MAINTENANCE INSTRUCTIONS (cont'd)

3.20A 18 *METER TUBE CLEANING*

To remove metering tube loosen the 4 screws at the bottom meter fitting. Press downward on the tube and tilt out at the top until tube is clear of top meter fitting. Remove float carefully and clean tube by pushing through a clean lint free swab dampened with a cleanser. Use clean dry swab to dry tube.



Drawing No. 3.20-S

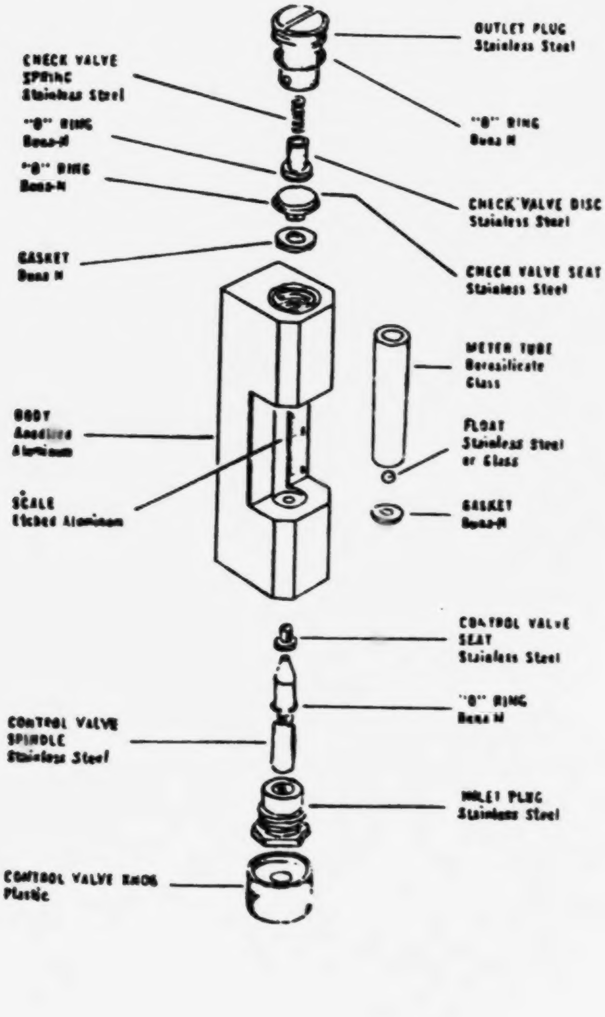
CONTROLS — 3.31

3.31D *ROTAMETER*

Check bubble line. If rotameter has a marking on the panel, check that the setting corresponds to the mark.

MANUAL PURGE

1. Depressing a button or moving a switch or valve on or in the panel marked "purge" will automatically shut off the air to the pressure mechanism and provide a direct flow of air to the compression bell, thereby purging the line. When released or switch thrown back to operate, controls go back to normal operation.


OUTLET PLUG
Stainless Steel
CHECK VALVE SPRING
Stainless Steel
"O" RING
Buna-N
"O" RING
Buna N
"O" RING
Buna-N
CHECK VALVE DISC
Stainless Steel
GASKET
Buna N
CHECK VALVE SEAT
Stainless Steel
METER TUBE
Borosilicate Glass
BODY
Anodized Aluminum
FLOAT
Stainless Steel or Glass
SCALE
Etched Aluminum
GASKET
Buna-N
CONTROL VALVE SEAT
Stainless Steel
"O" RING
Buna N
CONTROL VALVE SPINDLE
Stainless Steel
INLET PLUG
Stainless Steel
CONTROL VALVE KNOB
Plastic

Rotameter
Drawing No. 3.31A

BEST COPY AVAILABLE

COUPLING — 3.40
MAINTENANCE INSTRUCTIONS

3.40A *GENERAL*

Unless couplings between the ends of the driving shaft and driven shaft of a pump or any other piece of equipment are kept in proper alignment, breaking or excessive wear result in either or both the driven machinery and the driver. Burned out bearings and sprung or broken shaft are some of the damages caused by misalignment. To prevent these damages, periodic checking and maintenance must be performed. Any maintenance performed on couplings, either checking or realignment, must be done with the motor switch in "off" position and special lock on the panel switch.

1. Flexible couplings permit easy assembly of equipment, but must be checked for both horizontal and vertical alignment. Distance between coupling halves must be exactly the same at all points. A straight edge must have continuous contact when laid across both couplings. Set screws must be tight and if found continually loose must be replaced. Realign when necessary.
2. If there is a shield or guard over the coupling, check that bolts are tight and guard will not in any way touch the coupling or shaft.

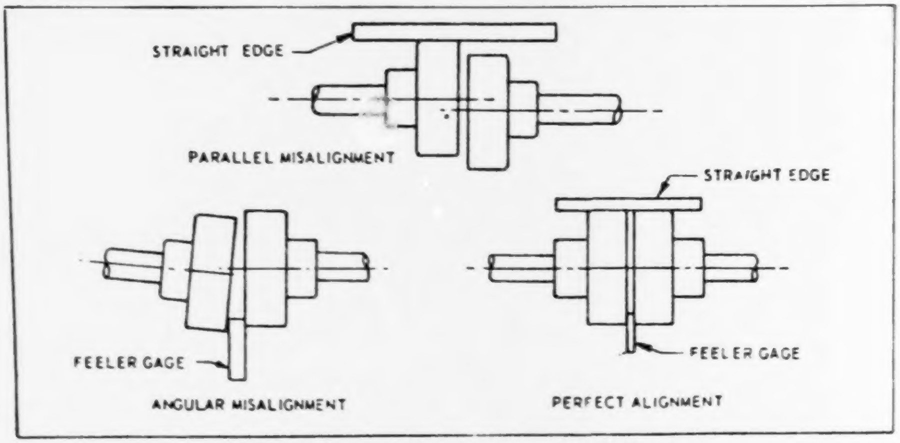
3.40B *CHECK FLEXIBLE COUPLING*

Realign when necessary, using a straight edge and thickness gage or a Dial indicator.

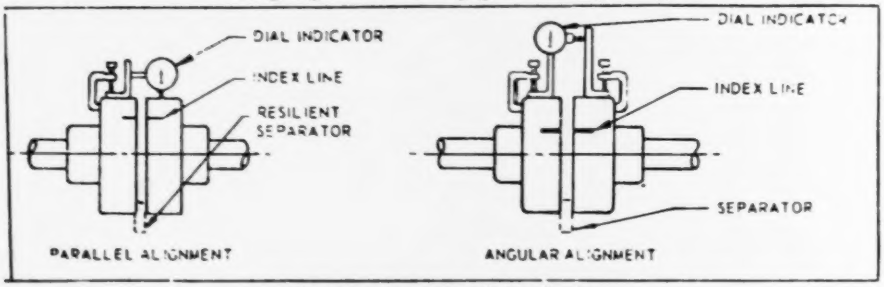
1. Remove coupling pins, rigidly tighten driven equipment, slightly tighten bolts holding the drive. To correct horizontal and vertical alignment, shift and shim drive to bring coupling halves into position so no light can be seen under a straight edge laid across them. Place straight edge in four positions. Hold a light back of the straight edge to help insure accuracy. Check angular misalignment with a thickness or feeler gage inserted at four places to make certain space between the coupling halves is exactly the same at all points. When proper alignment has been secured, coupling pins can be put in place easily using only finger pressure. Never hammer pins into place.
2. In couplings where pins are solid on the coupling halves and fit into rubber eyelets, or couplings which mesh together with rubber or nylon inserts, if properly aligned and loose on the shafts, coupling halves should slide together with finger pressure.
3. To check coupling alignment with a dial indicator, disconnect the coupling halves. Fix a dial indicator to one of the shafts or coupling hubs. Span the indicator arm across the mating shaft or coupling hub. Scribe index lines on the coupling halves or mark where the indicator point rests. Set indicator dial to zero. Slowly turn both coupling halves so that the index lines match, or indicator point is always on the mark. Observe dial reading to determine whether driven or driver needs adjustment. Acceptable parallel alignment and acceptable angular alignment occurs when one half of the total indicator reading (complete turn), does not exceed manufacturer's limits.

These limits depend upon size and speed of the coupling. Refer to manufacturers specification limits. Correct parallel and angular misalignment by slightly shifting the leveling shims under the base plate of the driver. Retest after each shifting of shims.

COUPLING ALIGNMENT



Testing alignment, feeler gage and straight edge



Testing alignment, dial indicator
Drawing No. 3.40C

DEHUMIDIFIER — 3.50 MAINTENANCE INSTRUCTIONS

3.50A *OPERATIONAL CHECK*

Set dehumidifier dial on dry for normal operation. Check for condensation on the walls of the station. If condensation is noted, reset dehumidifier to very dry until moisture is cleared up. If the coils of the dehumidifier are frozen or frosted, turn the unit off until they defrost.

3.50B *LUBE AND INSPECT UNIT*

Disconnect the cord from the wall outlet. Disassemble the dehumidifier. Clean throughout, including drip pan and drain hose. Lube fan motor with about three drops of light oil. Reassemble. Replace the cord plug in the wall outlet and test.

ELECTRIC MOTORS - 6.01 MAINTENANCE INSTRUCTIONS

6.01A *CONDITION CHECK*

1. Keep motors free from dirt and dust.
2. Keep operating space free from articles which may obstruct air circulation.
3. Check for excessive grease or oil leakage from bearing fill lines and drain lines.

6.01B *UNUSUAL CONDITION CHECK*

Note and record in the station log, any of the following conditions:

1. Unusual operating noises,
2. Motor failing to start or come to speed normally,
3. Motor or bearings which feel or smell hot,
4. Continuous or excessive sparking of the commutator or brushes,
5. Intermittent sparking at brushes,
6. Hot or blackened commutator,
7. Brush chatter,
8. Smoke, charred insulation, or solder whiskers, extending from the armature,
9. Excessive humming,
10. Regular clicking,
11. Rapid knocking,
12. Virbration, and
13. Fine dust under couplings having rubber buffers or pins.

6.01C *LUBE FLUSH*

1. Turn motor to "off" position. If there is a lock out switch, lock on panel switch of the motor you are preparing for lubrication.
2. Wipe pressure gun fitting, bearing housing and relief plug with a clean rag.
3. Before using grease gun always remove relief plug, opposite side of bearing from grease fitting. This will prevent excessive pressure in housing which might rupture bearing seals.
4. Use clean screwdriver or similar tool to remove hardened grease from relief hole and permit excess grease to run freely from bearing.
5. Remove all fittings, tools, and rags from the motor.
6. Place the unit back in service. Start the motor. While motor is running, add grease with hand-operated pressure gun unit until it flows from relief hole.

6.01F *SCOPE BEARINGS*

Check all bearings using a stethoscope. Listen while the motor is being started and shut off. Listen also during motor operation for whines, gratings or uneven noises in several locations around the bearing housing as close as possible to the bearing. If the unusual noises are heard, pinpoint the location, record it in the station log, and report the condition to the responsible Maintenance Foreman.

ELECTRICAL MOTOR ISOLATION

Place the electrical control switch which is in the control panel in the off position and lock in the off position with the special lock. If there is a secondary switch at the motor, lock this in the off position also. Both switches on off position will insure against accidental power supply.

METERS - 6.10

6.10J *COUNTER-GALLONS-HOUR*

1. Where a unit is equipped with a counter or a register to record gallons pumped or a register to record hours the unit has run, take the reading from the counter or register and record it on a special log sheet provided for that purpose by following directions on the sheet. When reading meters with a revolving register, note if there are zeros (00) printed on face of the meter at the right of the revolving figures. If there are zeros, add them to the register number. Also check to see what the meter reading measure is such as cu. ft. or gallons. Log the units of measurement. For example, if the meter reading is in gallons and there are two zeros, a register number of 7439 would be logged on the form as 743900 gals. Also any meters or gages registering amps, volts, or air, take the reading from the panel gage or meter if so requested.

FLOW RECORDER

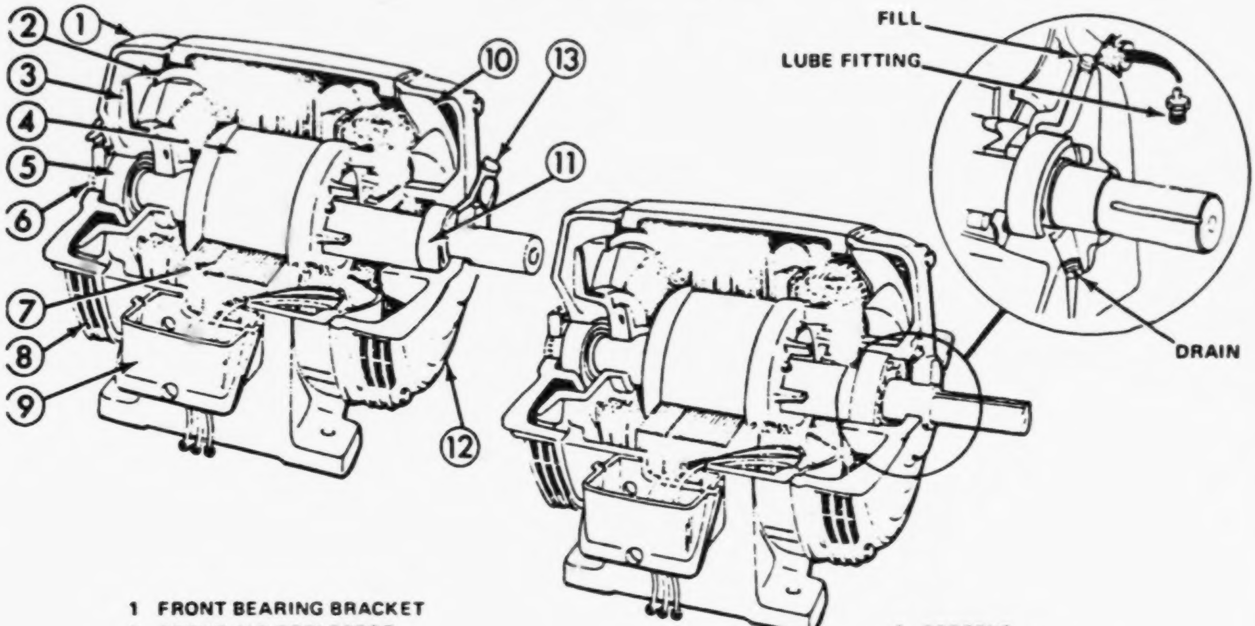
2. The flow recorder is regulated by a magnetic flow meter on discharge line. A fold chart receives the resultant signal and is recorded by pen and ink system. There is a recording of P.S.I. on the same fold chart.

6.10K *ELECTRIC POWER METERS*

1. There are various types of electric meters. The most common and more frequently used meter has four or five registers or dials with pointers. Two of the pointers move in one direction, the others in the opposite direction. To read and log a meter of this type, write down from left to right the numbers the pointers *HAVE PASSED*. Before writing down any number the pointer has passed, always check the direction of the pointer to get the correct number. Suppose one of the pointers points directly to the "4." Before writing down 4, look at the pointer on the dial to the right, if it has not quite reached the "O" then the pointer which seemed to point directly to 4 has not actually reached the 4, so write down 3 instead. If the pointer to the right has passed the "O" then the correct number would be 4.

ELECTRIC MOTOR — 6.01

MOTOR LUBRICATION

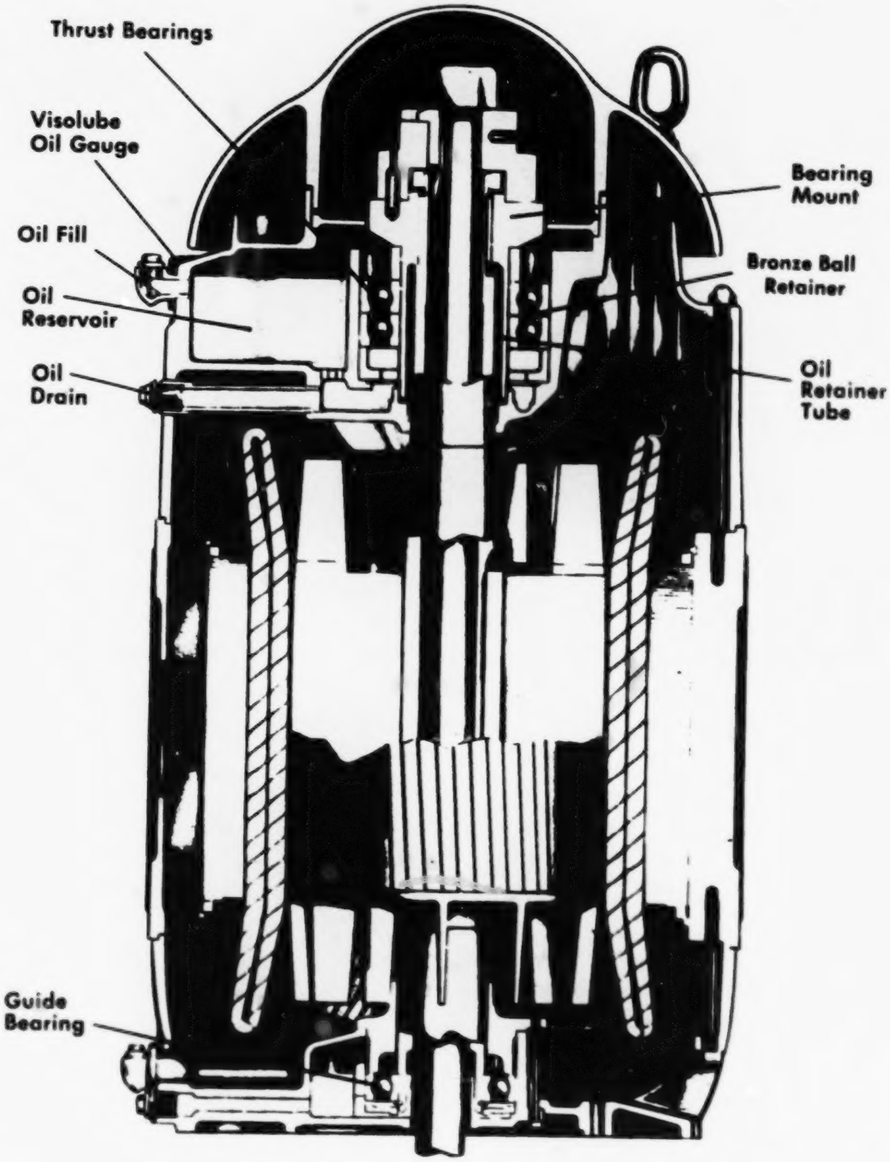

①
②
③
④
⑤
⑥
⑦
⑧
⑨
⑩
⑪
⑫
⑬
FILL
LUBE FITTING
DRAIN

1 FRONT BEARING BRACKET
2 FRONT AIR DEFLECTOR
3 FAN
4 ROTOR
5 FRONT BEARING
6 END COVER
7 STATOR
8 SCREENS
9 CONDUIT BOX
10 BACK AIR DEFLECTOR
11 BACK BEARING
12 BACK BEARING BRACKET
13 OIL LUBRICATION CAP

Electric Motor
Lubrication

Drawing No. 6.01B

ELECTRIC MOTOR — 6.01


Thrust Bearings
Visolube Oil Gauge
Oil Fill
Oil Reservoir
Oil Drain
Bearing Mount
Bronze Ball Retainer
Oil Retainer Tube
Guide Bearing

Motor Bearing
Lubrication

Drawing No. 6.01C

2. A special log sheet can be provided to log the meter reading. On some meters there may be a notation to multiply the reading by 40 or 1600 or some other figure. Put this multiplication factor in the space provided. If previous and present readings are required, use direct meter readings and subtract before multiplying by the multiplication factor.

WET PITS - 7.10
MAINTENANCE INSTRUCTION

7.10A *INSPECTION AND CLEANING*

1. When cleaning a wet pit, manhole or sump (where water pressure is available either at the station or portable water tank with pressure), check the pit for any floating debris which might plug or damage a pump.

   If there is debris, remove it.

   Use a hose and nozzle to wash the solids off the pit walls while the pit is being pumped down.

   If solids are heavier than normal, pump out by stages.

   If water pressure does not remove the solids from the walls, the pit walls must be scraped.

DEFINITION OF WET PIT OR ENCLOSED AREA is defined by the State of California, Division of Industrial Safety as: The interior of storm drains, sewers, vaults, utility pipe lines, manholes, and any other structure which is similarly surrounded by confining surfaces so as to permit the accumulation of dangerous gases or vapors.

WASTEWATER PUMPS - 7.20
ISOLATION INSTRUCTIONS

PREREQUISITES:

Prior to the electrical isolation of a wastewater pump, ensure that the motor and pump are operating.

ELECTRICAL ISOLATION:

Place the electrical control switch in the off position and lock in the off position with the special lock. There is a secondary lock out switch at the motor for the purpose of eliminating power to unit without using the switch panel. Both switches in off position will insure against accidental power supply.

CLOSE ALL VALVES.

RESTORATION:

Open all valves.

ELECTRICAL:

Unlock power supply switches and place in the on position.

OPERABILITY DEMONSTRATION:

Demonstrate the wastewater pump is operable by starting the pump and observing if it is operating normally.

WASTEWATER PUMPS - 7.20
MAINTENANCE INSTRUCTIONS

After the unit has run for a short period under normal operating conditions, it should be shut down and checked for alignment. All alignment checks must be made with the coupling halves disconnected and again after they are connected. Remember that the correction of alignment in one direction may alter the alignment in the other direction; therefore, it is necessary to recheck in all directions after making any adjustment. As in any piece of precision machinery, it is economical to keep your pumping unit in the best operating condition by checking the alignment periodically.

The stuffing box packing is subject to wear and should be given regular attention. If normal inspection indicates that the stuffing box is operating satisfactorily with no excessive heat or leakage of the sealing liquid, it should not be tampered with. However, if leakage of the sealing liquid has increased and cannot be reduced by a slight tightening of the glands, it is time to shut down the unit and repack the box or check the sleeve surface for roughness.

When the pump starts to show normal wear, it is advisable to order replacement parts, thus avoiding excessive lost time which may occur if repairs are not ordered until the pump breaks down. Scoping bearings will determine pending bearing failure.

7.20A *WATER SEAL PACK GLANDS*

1. See that the packing box is protected with a clear water supply at all times. Make sure that pressure at water seal valve entrance is not less than pump shut off head. Check water line pressure gage. Check packing gland for leakage. The packing is subject to wear and should be given regular attention. If normal inspection indicates that the packing is operating satisfactory with no excessive heat or leakage of the sealing liquid, it should not be tampered with. However, if excessive leakage is found, tighten gland nuts evenly just enough to stop excessive leakage. After adjusting gland, be sure shaft turns freely by hand. A strap wrench may be needed on large pumps. If serious leakage continues, renew packing.

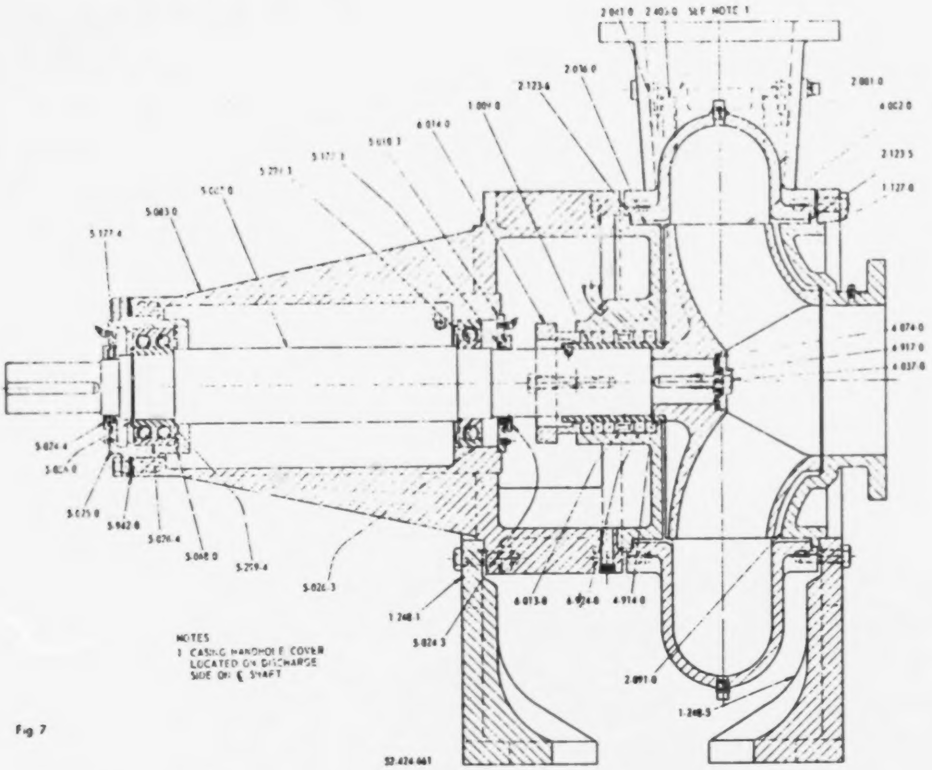
7.20B *GREASE SEAL PACK GLANDS*

1. When grease is used as a packing seal, maintain constant pressure on the packing during operation. When a grease cup is used, keep it loaded with proper lubricant. Turn the cap down two or three turns until resistance is felt. If this uses part of the grease in the cup, remove and refill. When greasing a fitting, two or three strokes of the gun is enough.

7.20E *CONDITION CHECK*

1. Keep exterior of pump clean. Keep drains open. Run pump manually. Check if pumping at full capacity. This can be done numerous ways, depending on the design of the

PUMP CENTRIFUGAL - 7.20


2 041 0
2 405 0
SEE NOTE 1
2 036 0
2 123 6
1 009 0
6 014 0
5 018 3
5 177 3
5 299 3
5 007 0
5 083 0
5 177 4
2 001 0
4 002 0
2 123 5
1 127 0
4 074 0
4 917 0
4 037 0
5 024 4
5 086 0
5 025 0
5 942 0
5 026 4
5 068 0
5 299 4
5 026 3
1 248 1
5 024 3
6 013 0
6 924 0
4 914 0
2 091 0
1 248 5
52 424 661

NOTES
1 CASING HANDHOLE COVER LOCATED ON DISCHARGE SIDE OF ℄ SHAFT

Fig 7

Cat. No.	Name	Cat. No.	Name
1-009-0	Shaft Sleeve	5-018-3	Bearing Cover
1-127-0	Cover Clamping Ring	5-024-3	Deflector (Inboard)
1-248-1	Foot Support (outboard)	5-024-4	Deflector (Outboard)
1-248-5	Foot Support (inboard)	5-025-0	Bearing Cartridge
2-001-0	Casing	5-026-3	Ball Bearing (Inboard)
2-036-0	Stuffing Box Cover	5-026-4	Ball Bearing (Outboard)
2-041-0	Handhole Cover (Casing)	5-068-0	Snap Ring (Bearing Cartridge)
2-091-0	Suction Cover	5-083-0	Frame
2-123-5	Gasket (Suction Cover)	5-086-0	Snap Ring (Shaft)
2-123-6	Gasket (Stuffing Box Cover)	5-177-3	Grease Seal (Inboard)
2-405-0	Handhole Cover Gasket (Casing)	5-177-4	Grease Seal (Outboard)
4-002-0	Enclosed Impeller	5-299-3	Grease Retainer (Inboard)
4-037-0	Impeller Screw	5-299-4	Grease Retainer (Outboard)
4-074-0	Impeller Washer	5-942-0	Adjusting Shims
4-914-0	"O" Ring (Impeller)	6-013-0	Seal Cage
4-917-0	Retaining Washer	6-014-0	Gland (Split)
5-007-0	Shaft	6-924-0	Packing (Set)

Drawing No. 7.20-A

station. Check the discharge if convenient. Watch the check valve. Watch the lowering of the pit. Check for excessive grease or oil leakage from the bearings. Look for black powdery substance near bearings or shaft. Note if pump feels or smells hot. Note any unusual noises or vibrations. Check guards and shields.

7.20G *OPERATE PUMPS ALTERNATELY*

1. If alternator is not installed and two or more pumps of the same size are installed, alternate their use to equalize their wear.
2. Switches are marked either alternator or selector. In some electrical installations a pump will not run on manual unless the selector switch is turned to that particular pump. Thus, if you wish to run #1 pump on manual, turn the selector switch to #1.

7.20H *LUBRICATION*

1. The importance of proper lubrication cannot be over emphasized. It is difficult to say how often a bearing should be greased since that depends on the conditions of operation. One ounce of grease should be added at regular intervals, but it is of equal importance to avoid adding too much grease. Excess grease is the most common cause of overheating. If possible remove the bearing cover and visually inspect the grease in the housing. If unable to remove the cover, remove the relief plug and add grease cautiously (five or six strokes of the gun are enough).

7.20N *WATER LUBE LINE CHECK*

1. Close the gate valve or shut-off cock in the water supply line to the pump packing box. Disconnect the water lube line at the union and remove the section of the line from the union to the packing box. In case of a flexible hose, remove at the packing box inlet. Check the inlet to the lantern ring for grease or particles of packing. Start the pump, slowly open the supply line valve. The solenoid valve in the lube line should now be open and water flowing through the line. Shut off the pump; this should stop the flow of water as the solenoid valve should automatically close. Reinstall the lube line. If it consists of pipe, use suitable thread compound. Make sure the gate valve or shut-off cock is fully open. Put the unit back in service. Run the pump. Check the packing leakage; adjust if necessary.

7.20P *PUMPING RANGE* (On and Off levels)

1. Wastewater lift, storm drain and other types of pumps may have an automatic set pumping range. The control for the range can be a bubble line, float, electrode or in case of a water well pump, a pressure switch. The test is to check the on and off levels which are set for all pumps unless manually operated. There are several ways of checking pumping levels. One way is with a moderate or good flow of water, allow the pit to fill until the lead pump comes on automatically. Check that the pump starts at the correct level. Shut this pump off and let the pit keep filling up until the second pump starts. Check the starting level of this pump and continue with the same procedure until all pumps have been tested for starting level. Next turn all pumps on automatic and check the stop level as each one stops. Variations of this procedure will have to be made due to installation of the controls in a particular station. For example one pump may be set not to run while two others are running, thus this pump would have to be checked independently. Make sure all pump switches are on automatic before leaving the station. With water well pumps and pressure switches, test the pressure on and off range. As there is a delay on water well pumps before starting, it would be more accurate to watch the mercoid switch to see that it trips at the correct pressure. Should it be necessary, the well can be isolated by closing the tank outlet valve. Then the water can be drained by opening the tank drain valve until the pressure is down and the pump comes on automatically. Close the drain valve. Check both on and off settings. After checking the range, open the outlet valve. At anytime any pumping levels do not correspond with the settings for the station pumps and the reason cannot be readily found and corrected, report it to your foreman.

SUMP PUMPS — 7.20L
MAINTENANCE INSTRUCTIONS

7.20L 1 *OPERATIONAL CHECK*

Fill the sump basin and verify that the pump starts automatically and stops at the proper level.

7.20L 2 *INSPECTION*

A. Pump all the water possible out of the basin. Isolate the sump pump according to isolation instruction.

B. Disconnect the pump at the union and remove from the basin.

C. Remove the bottom cover or strainer and check the impeller. Clean the entire unit of rust, grease or corrosion.

D. Check the float for pin holes or wear spots. Replace if necessary.

E. Put a thin film of grease or oil on the float rod and rod guides.

F. Before returning the sump pump to the basin, test the check valve by slowly opening the discharge gate valve. If water flows from the line, the check valve is leaking. In this situation, close the gate valve and repair or replace the check valve.

G. Clean the basin thoroughly and reinstall the pump.

H. Restore the pump to service according to isolation instruction.

Fill the sump basin until the pump automatically starts. Verify that the pump operates smoothly and then stops at the proper level.

ISOLATION INSTRUCTION

A. *PREREQUISITES*

Prior to the isolation of the sump pump, pump the basin as dry as possible.

B. *ELECTRICAL ISOLATION*

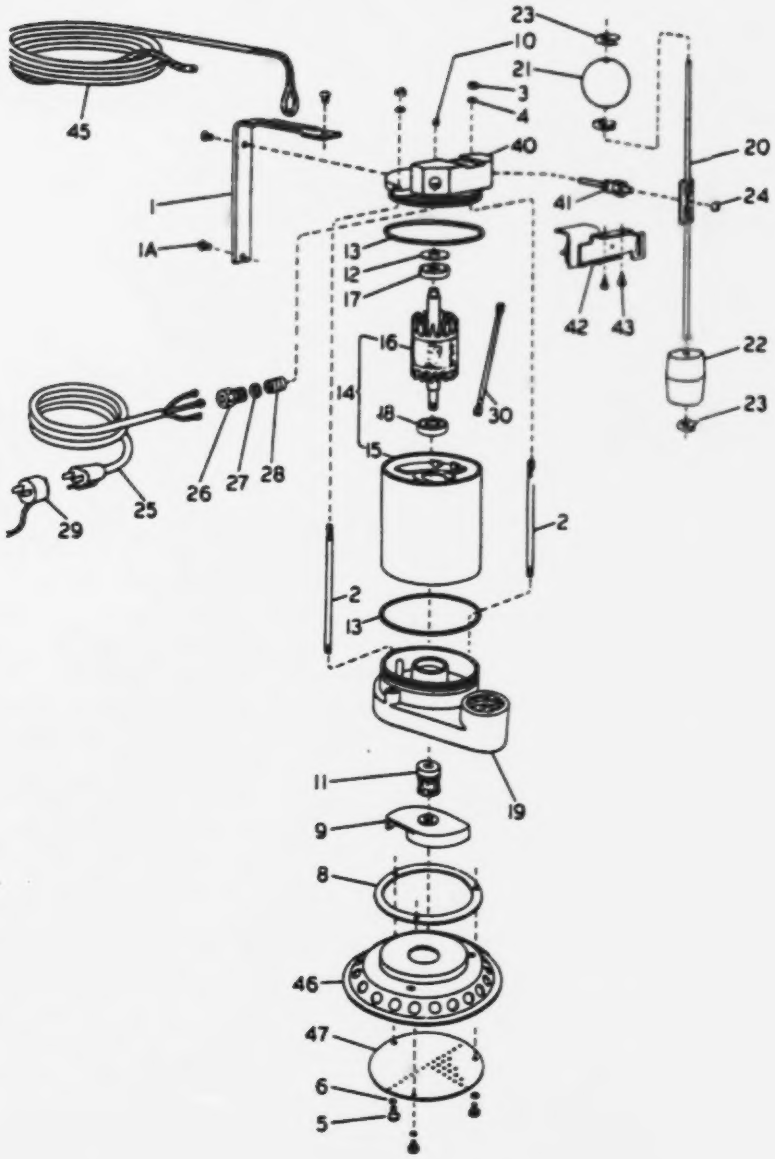
Remove the sump pump fuse or remove the electrical plug from the wall outlet, whichever is applicable.

C. *MECHANICAL ISOLATION*

Close the discharge gate valve.

D. *RESTORATION*

1. Open the discharge gate valve.
2. Replace the sump pump fuse or reconnect the electrical plug to the wall outlet.



Drawing No. 7.20-C

Model PCD-6 **⅓ HP, 115V.**

REPAIR PARTS LIST

Key No.	Part Description	No. Used	Part Symbol
1	Handle	1	PS54-5
1A	Machine Screw #10-24 x 5⁄16" Lg. Truss Head	3	U30-583C
2	Stud — ¼-20 x 7⅜" Lg.	2	U30-619C
3	Nut — ¼-20 Hex	2	U36-36C
4	Lockwasher — ¼"	2	U43-10C
5	Capscrew — ¼-20 x ½" Lg. Hex Hd.	3	U30-50C
6	Washer — Plain — ¼"	3	U43-60C
8	Gasket (as Req'd.)	1	PS20-3
9	Impeller	1	PS5-2P1C
10	Pipe Plug — ¼" NPT Soc. Hd.	1	U78-95C
11	Shaft Seal — John Crane Type 6	1	U9-103
12	Bearing Loading Spring 202	1	PS18-7
13	"O" Ring 5⅛ x 5⅜ x ⅛	2	U9-114
14	Motor — ⅓ HP, 115 V	1	PS118-15
15	Stator	1	PS18-35
16	Rotor	1	PS18-34
17	Bearing — MRC #7109	1	U18-682
18	Bearing — MRC #203SFZ	1	U18-628
19	Volute	1	PS1-7BB
20	Float Rod Assembly	1	PS128-3
21	Float — 2½" Dia. x ⅛" Hole	1	PS28-7
22	Weight (Control #502)	1	PS28-6
23	Speed Clip #C26046SS-014-27	3	PS28-8
24	Float Rod Ring	1	PS28-3
25	Cord & Plug (25' Lg.)	1	U17-337
26	Packing Gland	1	PS16-1
27	Washer	1	PS43-1
28	Packing Ring	3	PS21-1
29	Adapter Plug	1	U17-99
30	Lead — Switch to Motor	1	PS18-30
40	Upper End Bell	1	PS3-8B
41	Lever Arm Assembly	1	PS178-2
42	Micro Switch Assembly	1	U117-310
43	Machine Screw #8-32 x 1/4" Lg. Rd. Hd.	2	U30-111C
45	Plastic Rope (24' Lg.)	1	U97-21
46	Base	1	S4-7D
47	Strainer	1	S8-7

STRAINERS — 7.94
MAINTENANCE INSTRUCTIONS

7.94A *INSPECTION AND CLEANING*

1. Single basket strainers are only used where flow can be interrupted as equipment must be shut off and valves closed to remove and clean the basket.
2. Twin strainers are cleaned without interrupting the flow. There are several types, one having a flow switch valve which will divert the flow from one basket to the other, thus permitting removal of the out of service basket for cleaning. The access covers of the chambers may have an air release cock. If so, open the pet cock before removing the cover. Another type of strainer has two gate type sliding valves. In this type both valves are always turned the same way, thus opening one passage through the strainer and closing the other.
3. If there is a valve at the base of the strainer or sand trap, open this valve and flush until water runs clear.

VALVES — AIR RELIEF — 8.10

8.10C 4 *CHECK AIR RELIEF VALVE*

To inspect and clean water tank air relief valves, close the gate valve in the air line and the gate valve in the water line to the air relief valve. Open the drain valve to relieve pressure. Remove the air valve from the line. Disassemble. Check float ball, spring, needle valve and orifice. Clean out all rust and corrosion. Reassemble. Check that the needle valve and orifice are aligned and that the spring is operating correctly. Flush the water line before replacing the air relief valve.

VALVES — 8.30
MAINTENANCE INSTRUCTIONS

8.30 *VALVES*

A. Operate inactive gate valves to prevent sticking.

B. Adjust the stem stuffing box packing tight enough that it will not leak, but not so tight that the stem turns with difficulty.

C. Lubricate the packing with a few drops of oil to eliminate excessive friction between the valve stem and the packing.

Modern gate valves can be repacked without removing them from service. Before repacking, verify the gate valve is in the fully opened position. This will prevent excessive leaking when the packing is removed.

REPACKING

REPACK GATE VALVE AS FOLLOWS:

A. Remove all packing from the stuffing box,

B. Clean the valve stem with fine emery cloth,

C. Insert new split ring packing in the stuffing box, staggering the joints and tamping down while inserting, and

D. Place a few drops of oil on the stem and tighten down the packing just enough to keep it from leaking.

8.30D *BALL VALVE* (AUTO. STOP AND CHECK)

1. Check operation. Lightly oil the stem. Exercise the hand control and lightly oil the stem threads.
2. To clean and inspect the strainer screen in the water line to the control valve of the Ball Valve, close the incoming line gate valve, remove the screen, clean and inspect. Replace if necessary. Flush the line by momentarily opening the gate valve. Replace the screen and open the gate valve.

8.30E *GLOBE VALVES*

Operate globe valves to prevent sticking. Check valve for leakage. Replace discs if necessary. Lube stem and packing with one or two drops of oil.

8.30F *BURIED VALVES*

Operate inactive valves. Lubricate buried valves, if possible, by pouring oil down a pipe.

SLIDE GATE - 8.40

8.40C *HYDRAULIC GATE OPERATOR*

1. Periodically check tank fluid level. Level should be at the middle of the gage. Check the system pressure. Inspect piping for leaks.
2. Replace hydraulic fluid. Drain the reservoir and fill to the middle of the sight gage. Oil should be filtered and all containers and funnels clean. If equipped with pump and hydraulic motor cases with external drain connections, remove the plug (or tubed drain connection where there is no plug) and fill the case with hydraulic fluid. Then replace the plug. Clean suction strainers and replace filter elements.

WATER WELLS - 9.01

A. *CLEAN-INSPECT WATER TANK INTERIOR*

Place motor switch in off position, and lock out the controls. Close the tank discharge gate valve. Open the tank drain gate valve and drain the tank. Remove the inspection cover and 8-inch blind flange on the opposite end of the tank. In large tanks that can be entered, install an electric fan or blower in the hole where the blind flange was removed. Purge the tank ten minutes before entering. Remove sand, clean and inspect the tank. Record amount of sand removed and condition of the tank. Remove the fan and reinstall the blind flange. Pour one gallon of chlorine solution into the tank. Replace the inspection cover, close the drain gate valve and put the unit back in service with the selector switch on automatic. Let the tank fill to its normal capacity, then let water and chlorine solution stand in tank for one-half hour. Drain and flush the tank until chlorine residual is below one-half mg/L. After this is accomplished, fill the tank with water and open the tank discharge gate valve.

B. *WATER TANK MAINTENANCE*

1. Check for leaks, water and air, all lines, valves, etc.
2. Check tank contents by the glass tube sight glass. Water level would be gaged by the length of the air relief valve line. Clean the sight glass tube if necessary. If the water tank is water logged, (too much water and not enough air), isolate the tank by closing the tank outlet valve. Turn the pump switch to off position. Open the tank drain valve and drain enough water out to leave the tank about ⅓ full of water. Close the drain valve and turn the pump switch to manual. When the pump starts, watch the check valve lever. When it shows the flow is full and continuous, shut off the pump and let it back spin. This draws air in through the inlet valve. As soon as the pump stops back spinning, start it again. This will force into the tank the air drawn in by the back spin. Continue this procedure until the proportion of air and water is correct. Open the tank outlet valve and place the switch on automatic. If there is a time clock on the well pump, reset the clock. If the proportion of air is too great, see Par. 8.10 C-2.
3. When leaks occur around the glass tube, renew the packing. Renew the paint stripe on the back of the glass tube if worn or faded. If sight gage draining cock leaks, repair or replace.

C. *STANDING WATER LEVEL*

1. If there is an air line at the base of the water well pump motor frame with a water level gage attached, remove the cap from the valve stem and attach a hand air pump. Pump air into the line until water level indicator hand stops rising and remains constant. Record the reading on the maintenance sheet.
2. To sound a well with battery operated equipment, use the following procedure. This equipment will have either one long and one short wire or two long wires taped together wound on a reel or drum, connected in series with a battery and ammeter. Remove the cap from the pipe into the well casing. If the equipment has a short wire, clamp this wire to metal for a ground. (Metal base plate or discharge pipe). Lower the long wire slowly through the pipe into the well casing. When the wire touches the water, this will complete the circuit through the ground and the ammeter hand will move. The same holds true with two wires. When they touch the water, the circuit will be complete through the two wires and the ammeter hand will move. Mark the wire with a piece of tape or string at the top, at the center of the discharge. Remove from the casing and measure from wire ends to the place you marked on the wire. If the wire has been previously marked as to footage, measure from the footage mark below your mark to your mark. The total being the standing water level or distance from the center of the discharge to the water. Always shut off and lock off the pump before sounding the well.

CHAPTER 9

EQUIPMENT MAINTENANCE

by

Lee Doty

Revised by

Rick Arbour

This chapter (as well as the entire manual) has been reviewed by the Office of Water Programs, U.S. Environmental Protection Agency, and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Environmental Protection Agency. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the Environmental Protection Agency, California State University, Sacramento, California Water Pollution Control Association, authors of the chapters or project reviewers and directors.

TABLE OF CONTENTS

Chapter 9. Equipment Maintenance

Page

OBJECTIVES 125

GLOSSARY 127

LESSON 1

9.1 Beware of Electricity 129

9.2 Electrical Equipment Maintenance 129

- 9.21 Introduction 129
- 9.22 Volts, Amps, Watts and Power Requirements 131
- 9.23 Tools, Meters and Testers 132
- 9.24 Electrical System Equipment 135
  - 9.241 Need for Maintenance 135
  - 9.242 Equipment Protective Devices 135
  - 9.243 Fuses 136
  - 9.244 Circuit Breakers 136
  - 9.245 Ground 139
- 9.25 Motor Control/Supervisory Control and Electrical System 139

9.3 Motors 140

- 9.31 Types 140
- 9.32 Nameplate Data 140
- 9.33 Causes of Failure 143
- 9.34 Insulation 143
  - 9.341 Types and Specifications 143
  - 9.342 Causes of Failure 143
  - 9.343 Increasing Resistance Value 146
- 9.35 Starters 146
- 9.36 Safety 147
- 9.37 Other Motor Considerations 147
  - 9.371 Alignment 147
  - 9.372 Changing Rotation Direction 150
  - 9.373 Allowable Voltage and Frequency Deviations 153
  - 9.374 Maximum Vibration Levels 153
  - 9.375 Lubrication 153

9.38 Troubleshooting 153
9.381 Step-by-Step Procedures 153
9.382 Troubleshooting Guide for Electric Motors 156
9.383 Trouble-Remedy Chart for Induction Motors 158
9.39 Records 159

LESSON 2

9.4 Pumps 162
9.41 Let's Build a Pump 163
9.42 Pump Types and Parts 169
9.421 Centrifugal Pumps 169
9.422 Screw Pumps 169
9.423 Pneumatic Ejectors 174
9.424 Piston Pumps 176
9.425 Close-Coupled Pumps 178
9.426 Submersible Pumps 178
9.427 Centrifugal Trash Pumps 180
9.428 Positive Displacement Diaphragm Pumps 182
9.429 Positive Displacement Diaphragm (Pneumatic) Pumps 182

LESSON 3

9.5 Pump Components 186
9.51 Impellers 186
9.52 Shafts 189
9.53 Packing 191
9.54 Mechanical Seals 195
9.55 Bearings 197
9.56 Couplings 216
9.561 Purpose of Couplings 216
9.562 Direct-Coupled 216
9.563 Belt-Driven 218
9.564 Flexible Shafting 220

LESSON 4

9.6 Compressors 222
9.7 Lubrication 224
9.71 Purpose of Lubrication 224
9.72 Properties of Lubricants 224
9.73 Lubrication Schedule 225
9.74 Precautions 225
9.75 Final Cleanup and Inspection 226

9.8 Additional Reading 227

SUGGESTED ANSWERS 228

OBJECTIVE TEST 232

OBJECTIVES

Chapter 9. EQUIPMENT MAINTENANCE

After completion of Chapter 9 you should be able to do the following:

1. Explain the serious consequences that could occur when inexperienced, unqualified or unauthorized persons attempt to troubleshoot or repair electrical panels, controls, circuits, wiring or equipment,
2. Communicate with electricians by indicating possible causes of problems in electrical panels, controls, circuits, wiring and motors,
3. Properly select and use the following pieces of equipment (if qualified and authorized):
   a. Voltage testers,
   b. Ammeter,
   c. Megger, and
   d. Ohm meter,
4. Describe how a pump is put together,
5. Discuss the application or use of different types of pumps,
6. Maintain the various types of pumps,
7. Operate and maintain a compressor, and
8. Develop and conduct an equipment lubrication program.

ATTENTION

I. DO NOT ATTEMPT TO INSTALL, TROUBLESHOOT, MAINTAIN, REPAIR OR REPLACE ELECTRICAL EQUIPMENT, PANELS, CONTROLS, WIRING OR CIRCUITS UNLESS YOU

   A. KNOW WHAT YOU ARE DOING,

   B. ARE QUALIFIED, AND

   C. ARE AUTHORIZED.

   Section 9.2, Electrical Equipment Maintenance, is presented to provide you with an understanding and awareness of electricity. *THE PURPOSE OF THE SECTION IS TO HELP YOU PROVIDE ELECTRICIANS WITH THE INFORMATION THEY WILL NEED WHEN YOU CONTACT THEM AND REQUEST THEIR ASSISTANCE.*

II. Due to the wide variety of equipment and manufacturers in the wastewater collection field, detailed procedures for the maintenance of some types of equipment were very difficult to include in this chapter. Also manufacturers are continually improving their products and some details would soon be out of date. *FOR DETAILS CONCERNING THE OPERATION, MAINTENANCE AND REPAIR OF A PARTICULAR PIECE OF EQUIPMENT, REFER TO THE ENGINEER'S O & M MANUAL OR CONTACT THE MANUFACTURER.*

III. Effective equipment and sewer maintenance is the key to successful system performance. The better your maintenance, the better your facilities will perform. Abuse your equipment and facilities and they will abuse you. Everyone must realize that if the equipment can't work, no one can work.

GLOSSARY

Chapter 9. EQUIPMENT MAINTENANCE

ALTERNATING CURRENT (A.C.) ALTERNATING CURRENT (A.C.)

An electric current that reverses its direction (positive/negative values) at regular intervals.

AMPERAGE (AM-purr-age) AMPERAGE

The strength of an electric current measured in amperes.

AMPERE (AM-peer) AMPERE

The unit used to measure current strength. The current produced by an electromotive force of one volt acting through a resistance of one ohm.

BRINELLING BRINELLING

This type of bearing failure appears as tiny indentations (dents) high on the shoulder of the race.

CAUTION CAUTION

The word *CAUTION* is used to indicate that "equipment might be damaged if care is not taken." Also see WARNING and NOTE.

CAVITATION (CAV-uh-TAY-shun) CAVITATION

The formation and collapse of a gas pocket or bubble on the blade of an impeller. The collapse of this gas pocket or bubble drives water into the impeller with a terrific force that can cause pitting on the impeller surface.

CIRCUIT CIRCUIT

The complete path of an electric current, including the generating apparatus or other source; or, a specific segment or section of the complete path.

CIRCUIT BREAKER CIRCUIT BREAKER

A safety device in an electrical circuit that automatically shuts off the circuit when it becomes overloaded. The device can be manually reset.

CONDUCTOR CONDUCTOR

A substance, body, device or wire that readily conducts or carries electrical current.

COULOMB (COO-lahm) COULOMB

A measurement of the amount of electrical charge conveyed by an electric current of one ampere in one second. One coulomb equals about 6.25×10^{18} electrons (6,250,000,000,000,000,000 electrons).

CURRENT CURRENT

A movement or flow of electricity.

Water flowing in a pipe is measured in gallons per second past a certain point, not by the number of water molecules going past a point. Electric current is measured by the number of coulombs per second flowing past a certain point in a conductor. A coulomb is equal to about 6.25×10^{18} electrons (6,250,000,000,000,000,000 electrons). A flow of 1 coulomb per second is called 1 ampere, the unit of the rate of flow of current.

DIRECT CURRENT (D.C.) DIRECT CURRENT (D.C.)

Electrical current flowing in one direction only and essentialy free from pulsation.

ELECTROMOTIVE FORCE (E.M.F.) ELECTROMOTIVE FORCE (E.M.F.)

The electrical pressure available to cause a flow of current (amperage) when an electrical circuit is closed. See VOLTAGE.

ELECTRON ELECTRON

A very small, negatively-charged particle which is practically weightless. According to the electron theory, all electrical and electronic effects are caused either by the movement of electrons from place to place or because there is an excess or lack of electrons at a particular place.

FUSE FUSE

A protective device having a strip or wire of fusible metal which, when placed in a circuit, will melt and break the electrical circuit if heated too much. High temperatures will develop in the fuse when a current flows through the fuse in excess of that which the circuit will carry safely.

HERTZ (HURTS) HERTZ

The number of complete electromagnetic cycles or waves in one second of an electrical or electronic circuit. Also called the frequency of the current. Abbreviated Hz.

LEAD (LEE-d) LEAD

A wire or conductor that can carry electricity.

MANDREL (MAN-drill) MANDREL

A special tool used to push bearings in or to pull sleeves out.

NAMEPLATE NAMEPLATE

A durable metal place found on equipment which lists critical installation and operating conditions for the equipment.

NOTE NOTE

The word *NOTE* is used to "call attention to information that is especially significant in understanding and operating equipment." Also see WARNING and CAUTION.

MEGGER (from "megohm") MEGGER

An instrument used for checking the insulation resistance on motors, feeders, buss bar systems, grounds, and branch circuit wiring.

OHM OHM

The unit of electrical resistance. The resistance of a conductor in which one volt produces a current of one ampere.

POLE SHADER POLE SHADER

Separations on the iron core inside the coil of a magnetic starter.

RESISTANCE RESISTANCE

That property of a conductor or wire that opposes the passage of a current, thus causing electrical energy to be transformed into heat.

SHEAVE (SHE-v) SHEAVE

V-belt drive pulley which is commonly made of cast iron or steel.

SHIM SHIM

Thin metal sheets which are inserted between two surfaces to align or space the surfaces correctly. Shims can be used anywhere a spacer is needed. Usually shims are 0.001 to 0.020 inches thick.

VOLTAGE VOLTAGE

The electrical pressure available to cause a flow of current (amperage) when an electrical circuit is closed. See ELECTROMOTIVE FORCE (E.M.F.).

WARNING WARNING

The word *WARNING* is used to indicate that "hazardous voltages, currents and temperatures could cause personal injury or damage to equipment." Also see CAUTION and NOTE.

CHAPTER 9. EQUIPMENT MAINTENANCE

(Lesson 1 of 4 Lessons)

9.1 BEWARE OF ELECTRICITY

RECOGNIZE YOUR LIMITATIONS

In the wastewater collection and treatment maintenance departments of all cities, there is a need for maintenance operators to know something about electricity. Duties could range from repairing a tail light on a trailer or vehicle to repairing complex pump controls and motors. *VERY FEW MAINTENANCE OPERATORS DO THE ACTUAL ELECTRICAL REPAIRS OR TROUBLESHOOTING BECAUSE THIS IS A HIGHLY SPECIALIZED FIELD AND UNQUALIFIED PEOPLE CAN SERIOUSLY INJURE THEMSELVES AND DAMAGE COSTLY EQUIPMENT.* For these reasons you must be familiar with electricity, *KNOW THE HAZARDS*, and *RECOGNIZE YOUR OWN LIMITATIONS* when you must work with electrical equipment.

Most municipalities employ electricians or contract with a "commercial electrical company" that they call when major problems occur. However, the maintenance operator should be able to *EXPLAIN HOW THE EQUIPMENT IS SUPPOSED TO WORK AND WHAT IT IS DOING OR IS NOT DOING WHEN IT FAILS.*

After this lesson you should be able to tell an electrician what appears to be the problem with electrical panels, controls, circuits, and equipment. Even though operators may only be assigned maintenance tasks on electrical systems, the more operators know about electricity the better equipped they are to diagnose electrical problems, especially during emergency situations.

When an outside electrical contractor performs maintenance on your system, ask the contractor to assign the same person each time. This allows one person to become familiar with the pump station controls and electrical systems, and therefore, troubleshoot and repair much more rapidly during failures. This person should be accompanied by an assistant so backup people will be available with some knowledge of your system when the regular person is not available.

The need for safety should be apparent. If proper safe procedures are not followed in operating and maintaining the various electrical equipment used in wastewater collection and treatment facilities, accidents can happen that cause injuries, permanent disability, or loss of life. Some of the serious accidents that have happened and could have been avoided, occurred when machinery was not shut off, locked out, and tagged properly (Fig. 9.1), or when operators did not follow approved lockout procedures or OSHA requirements. Possible accidents include:

1. Maintenance operator could be cleaning pump and have it start, thus losing an arm, hand, or finger,
2. Electrical motors or controls not properly grounded could lead to possible severe shock, paralysis, or death, and
3. Improper circuit; such as, wrong connection, safety devices jumpered, wrong fuses, or improper wire. These mistakes can cause fires or injuries due to incorrect operation of machinery.

Another consideration for having a basic working knowledge of electricity is to prevent financial losses resulting from motors burning out and from damage to equipment, machinery and control circuits. Additional costs result when damages have to be repaired, including payments for outside labor.

WARNING

Never touch electrical panels, controls, circuits, wiring or equipment unless you are *QUALIFIED AND AUTHORIZED.* By the time you find out what you don't know about electricity, you could find yourself too *DEAD* to use the knowledge.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 228.

9.1A Why must unqualified or inexperienced people be extremely careful when attempting to troubleshoot or repair electrical equipment?

9.1B What could happen when machinery is not shut off, locked out, and tagged properly?

9.2 ELECTRICAL EQUIPMENT MAINTENANCE

9.21 Introduction

This section contains a basic introduction to electrical terms and information plus directions on how to troubleshoot problems with electrical equipment.

Most electrical equipment used in wastewater collection systems and treatment plants is labeled with nameplate[1] information indicating the proper voltage and allowable current in amps.

---

[1] ***Nameplate.*** *A durable metal plate found on equipment which lists critical installation and operation conditions for the equipment.*

DANGER

**MAN
WORKING
ON LINE**

**DO NOT CLOSE THIS
SWITCH WHILE THIS
TAG IS DISPLAYED**

SIGNATURE : ______________________

This is the ONLY person authorized to remove this tag.

Note: Tag also should include: TIME OFF ______________
DATE ______________

Fig. 9.1 Typical warning tag

(Source: Industrial Indemnity/Industrial Underwriters/Insurance Cos.)

9.22 Volts, Amps, Watts and Power Requirements

VOLTS

Voltage (E) is also known as Electromotive Force (E.M.F.), and is the electrical pressure available to cause a flow of current (amperage) when an electrical circuit is closed.[2] This force can be compared with the pressure or force that causes water to flow in a pipe. Some pressure in a water pipe is required to make the water move. The same is true of electricity. A force is necessary to push electricity or electric current through a wire. This force is called Voltage.

There are two types of Voltage: Direct Current (D.C.) and Alternating Current (A.C.).

DIRECT CURRENT

Direct Current (D.C.) is flowing in one direction only and is essentially free from pulsation. Direct current is seldom used in lift stations and wastewater treatment plants except in motor-generator sets, some control components of pump drives and stand-by lighting. Direct current is used exclusively in automotive equipment, certain types of welding equipment, and a variety of portable equipment. Direct current is found in various voltages, such as 6 volts, 12 volts, 24 volts, 48 volts, and 110 volts. All batteries are direct current. D.C. is tested by holding the volt meter leads on the positive and negative poles on a battery. These poles are usually marked Positive (+) and Negative (−). Direct current usually is not found in higher voltages (over 24 volts) around plants and lift stations unless in motor-generator sets. Care must be taken when installing battery cables and wiring that Positive (+) and Negative (−) poles are connected properly to wires marked (+) and (−). If not properly connected, you could get an arc across the unit that could cause an explosion.

ALTERNATING CURRENT

Alternating Current (A.C.) is periodic current which has alternating positive and negative values. In other words, it goes from zero to maximum strength, back to zero and to the same strength in the opposite direction which comprises a cycle. Our A.C. voltage is 60-cycle frequency, or "Hertz," which means that this happens 60 times per second. Alternating current is classified as:

a. Single Phase,
b. Two Phase,
c. Three Phase, and
d. Poly Phase.

The most common of these are single phase and three phase. The various voltages you probably will find on your job are 110 volts, 120 volts, 208 volts, 220 volts, 240 volts, 277 volts, 440 volts, 480 volts, and 550 volts.

Single-phase power is found in lighting systems, small pump motors, various portable tools and throughout our homes. It is usually 120 volts or 240 volts. Single phase means that only one phase of power is supplied to the main electrical panel at 240 volts and has three wires or leads. Two of these leads have 120 volts each, the other lead is neutral and usually is coded white. The neutral lead is grounded. Many appliances and power tools have an extra ground (commonly a green wire) on the case for additional protection.

Three-phase power is generally used with motors and transformers found in lift stations and wastewater treatment plants. This power generally is 208, 220, 240 volts, or 440, 460, 480 and 550 volts. Higher voltages are used in some lift stations. Three phase is used when higher power requirements or larger motors are used because efficiency is usually higher and motors require less maintenance. Generally all motors above two horsepower are three phase unless there is a problem with the power company getting three phase to the installations. Quite a few residential lift stations are on single-phase power due to their remote locations. Three-phase power usually is brought in to the point of use with three leads and there is power in all three leads.

When taking a voltage check between any two of the three leads, you measure 208, 220, 240 volts, or 440, 460, 480 volts depending on the supply voltage. There are some instances where you might measure a difference between the leads due to the use of different transformers. If there is power in three leads and if a fourth lead is brought in, it is a neutral lead.

Two-phase and poly-phase systems will not be discussed because they generally are not found in wastewater collection and treatment facilities.

AMPS

An Ampere (I) is the practical unit of electric current. This is the current produced by a pressure of one volt in a circuit having a resistance of 1 ohm. Amperage is the measurement of current or electron flow and is an indication of work being done or "how hard the electricity is working."

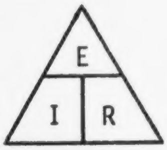
In order to understand amperage, one more term must be explained. The *OHM* is the practical unit of electrical resistance (R). "Ohm's Law" states that in a given electrical circuit the amount of current (I) in amperes is equal to the pressure in volts (E) divided by the resistance (R) in ohms. The following three formulas are given to provide you with an indication of the relationships among current, resistance and EMF.

$$\text{Current, amps} = \frac{\text{EMF, Volts}}{\text{Resistance, ohms}} \qquad \left(I = \frac{E}{R}\right)$$

$$\text{EMF, Volts} = (\text{Current, amps})(\text{Resistance, ohms}) \qquad (E = IR)$$

$$\text{Resistance, ohms} = \frac{\text{EMF, Volts}}{\text{Current, amps}} \qquad \left(R = \frac{E}{I}\right)$$

These equations are used by electrical engineers for calculating circuit characteristics. If you memorize the following relationship, you can always figure out the correct formula.



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[2] *Electricians often talk about closing an electrical circuit. This means they are closing a switch that actually connects circuits together so electricity can flow through the circuit. Closing an electrical circuit is like opening a valve on a water pipe.*

WATTS

The watt and kilowatt (one thousand watts) are measures of power units used to rate electrical machines or motors or to indicate power in an electrical circuit. The watts or power (P) required by a machine is obtained by multiplying the amps (I) required or pulled times the potential drop in volts (E) or the electromotive force (EMF). The amount of watts in a circuit is equal to the voltage (E) times the amperage (I). The total power in a circuit, measured in watts, at any given moment is similar to the power produced by a motor at any given moment in horsepower.

Power, watts = (Electromotive Force, volts) (Current, amps)

or P, watts = (E, volts) (I, amps)

1 HORSE-POWER
746 WATTS
0.746 KILO-WATTS
550 ft-lbs sec

For the sake of comparisons

1 horsepower = 746 watts = 0.746 kilowatts = 550 ft-lbs/sec

The actual horsepower output of a motor also depends on the power factor (a number less than one) and the efficiency of the motor.

$$\text{Output, hp} = \frac{(\text{P, watts})(\text{Power factor})(\text{Efficiency})}{746 \text{ watts/horsepower}}$$

POWER REQUIREMENTS

Power requirements *(Pr)* are expressed in kilowatt hours. 500 watts for two hours or one watt for 1000 hours equals one kilowatt hour. The power company charges so many cents per kilowatt hour.

Power req, kw-hr = (Power, kilowatts) (Time, hours)

Pr, kw-hr = (P, kw) (T, hr)

CONDUCTORS AND INSULATORS

A material, like copper, which permits the flow of electrical current is called a conductor. Material which will not permit the flow of electricity, like rubber, is called an insulator. Such material when wrapped or cast around a wire is called insulation. Insulation is commonly used to prevent the loss of electrical flow by two conductors coming into contact with each other.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 228.

9.22A What are two types of voltage?

9.22B Amperage is a measurement of what?

9.22C How can you determine the proper voltage and allowable current in amps for a piece of equipment?

9.23 Tools, Meters and Testers (Fig. 9.2)

> *WARNING*
>
> Never enter an electrical panel or attempt to troubleshoot or repair any piece of electrical equipment or any electrical circuit unless you are qualified and authorized.

In order to maintain, repair, and troubleshoot electrical equipment and circuits, the proper tools are required. In order to check for "VOLTAGE," a *VOLTAGE TESTER* is needed. There are several types on the market and all of them work. They are designed to be used on energized circuits and care must be exercised when testing. By holding one lead on ground and the other on a power lead, you can determine if power is available. You also can tell if it is A.C. or D.C. and the intensity or voltage (110, 220, 480, or whatever) by testing the different leads.

Do not work on any electrical circuits unless you are qualified and authorized. Use a voltage tester and other circuit testers to determine if circuit is energized, or if all voltage is off. This should be done after the main switch is turned off to make sure it is safe to work inside the electrical panel. Always be aware of the possibility that even if the disconnect to the unit you are working on is off, the control circuit may still be energized if the circuit originates at a different distribution panel. Check voltage tester before and during time switch is pulled off to have a double check. This procedure insures that the voltage tester is working and that you have good continuity to your tester. Use circuit testers to measure voltage or current characteristics to a given piece of equipment for making sure that you have or do not have a "live" circuit. *WARNING.* Switches can fail and the only way that you can be assured that a circuit is dead is to test the circuit.

Besides using the voltage tester for checking power, it can be used to test for open circuits, blown fuses, single phasing of motors, grounds, and many other uses. Some examples are illustrated in the following paragraphs.

In the circuit shown on page 133 (Figure 9.3), test for power by holding one lead of the tester on point "A," and the other at point "B." If no power is indicated, the switch is open or faulty. Sketch shows switch in "open" position.

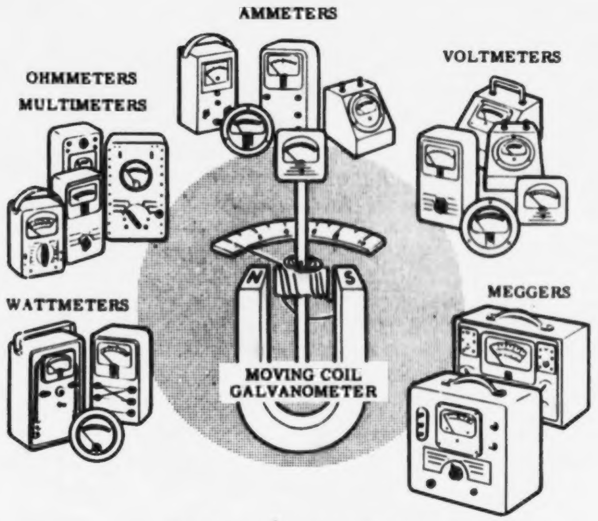

Fig. 9.2 Electrical meters

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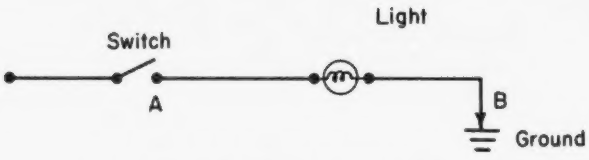


Fig. 9.3 Single-phase circuit

To test for power at Point "A" and Point "B" in Figure 9.4, open the switch as shown. Using a voltmeter or voltage tester with clamp-on leads, clamp a lead on L1 and a lead on L2 between the fuses and the load. Bring the voltage tester and leads out of the panel and close the panel door as far as possible without cutting or damaging the meter leads. Some switches cannot be closed if the panel door is open. The panel door is closed when testing because hot copper sparks could seriously injure you when the circuit is energized and the voltage is high. Close the switch.

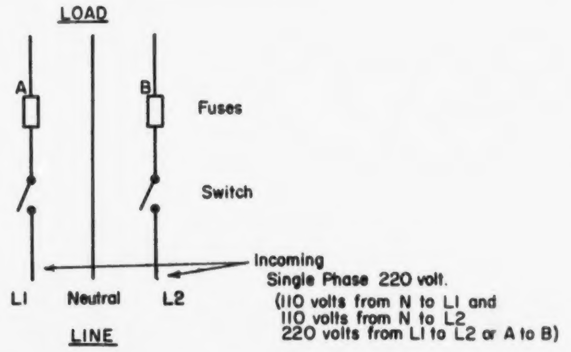


Fig. 9.4 Single-phase, three-lead circuit

1. Voltage tester should register at 220 volts. If there is no reading at points "A" and "B," the fuse or fuses could be "blown."
2. Move voltage tester down below fuses to line 1 and line 2 (L1, L2). If there is still no reading on the voltage tester, check for an open switch in another location, or call the power company to find out if power is out.
3. If a 220 volt reading is registered at line 1 and line 2, move the test leads to point "A," and the "neutral" lead. If a reading of 110 volts is observed, the fuse on line "A" is okay. If there isn't a voltage reading, the fuse on line "A" is "blown." Move the lead from line "A" to line "B." Observe the reading. If 110 volt power is recorded, the fuse on line "B" is "blown." Another possibility to consider is that the neutral line could be broken. Under these conditions, if there is voltage on line "A" and the fuse on line "B" is blown, voltage will appear on line "B."

WARNING — *TURN OFF POWER AND BE SURE THAT THERE IS NO VOLTAGE IN EITHER POWER LINE BEFORE CHANGING FUSES.* Use a *FUSE PULLER.* Test circuit again in the same manner to make sure fuses or circuit breakers are okay. 220 volts power or voltage should be present between point "A" and "B." If fuse or circuit breaker trips again, shut off and determine the source of the problem.

Test for power at points "A," "B" and "C" in three-phase circuit (Figure 9.5). Place voltage tester leads on lines "A" and "B." Close all switches. 220 volts should register on voltage tester. Check between lines "A" and "C," and between lines "B" and "C." 220 volts should be recorded between all of these points. If voltage is not present, one or all of the fuses are "blown" or the circuit breaker tripped. First check for voltage above the fuses at all of these points, "A" to "B," "A" to "C," and "B" to "C," to make sure power is available (See 220 readings in Figure 9.5). If voltage is recorded, move leads back down to bottom of fuses. If voltage is present from "A" to "B," but not at "A" to "C," and "B" to "C," the fuse on line "C" is "blown." If there weren't any voltage readings at any of the test points, all the fuses could be "blown."

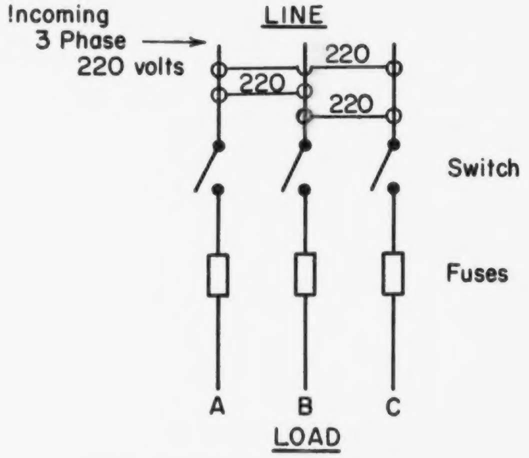


Fig. 9.5 Three-phase circuit, 220 volts

Another way of checking the fuses on this three-phase circuit would be to take your voltage tester and place one lead on the bottom, and one lead on the top of each fuse. You should *NOT* get a voltage reading on the voltmeter. This is because electricity takes the path of least resistance. If you get a reading across any of the fuses (top to bottom), that fuse is bad.

ALWAYS MAKE SURE THAT WHEN YOU USE A VOLTMETER IT IS SET FOR THE PROPER VOLTAGE. IF VOLTAGE IS UNKNOWN AND THE METER HAS DIFFERENT SCALES THAT ARE MANUALLY SET, ALWAYS START WITH THE HIGHEST VOLTAGE RANGE AND WORK DOWN. Otherwise the voltmeter could be damaged. Look at the equipment instruction manual or nameplate for the expected voltage. Actual voltage should not be much higher than given unless someone goofed when the equipment was wired and inspected.

Voltage readings are important because they determine how you connect motor leads, relays, and transformers. Low or high voltages can drastically affect motors.

Another meter used in electrical maintenance and testing is the *AMMETER*. The ammeter records the current or "amps" in the circuit. There are several types of ammeters, but only two will be discussed in this chapter. The ammeter generally used for testing is called a "clamp on" type. The term "clamp on" means that it can be clamped around a lead or each lead supplying a motor lead, and no direct electrical connection need be made. These are used by clamping the meter over only one of the power leads to the motor or other apparatus and taking a direct reading. Each "leg" or lead on a three-phase motor must be checked by itself.

The first step should be to read the motor nameplate data and find what the amperage reading should be for the particular motor or device you are testing. After you have this information, set the ammeter to the proper scale. Set it on a higher scale than necessary if the expected reading is close to the top of the meter scale. Place the clamp around one lead at a time. Record each reading and compare with the nameplate rating. If the readings don't compare with the nameplate rating, find the cause, such as low voltage, bad bearings, poor connections, plugging or excessive load. If the ammeter readings are higher than expected, the high current could produce overheating and damage the equipment. Try to find the problem and correct it.

When using a clamp-on ammeter, be sure the set the meter on a high enough range or scale for the starting current if you are testing during startup. Starting currents range from 110 to 150 percent higher than running currents and using too low a range can ruin an expensive and delicate instrument. Newer camp-on ammeters automatically adjust to the proper range and can measure both starting or peak current and normal running current.

Another type ammeter is one that is connected in line with the power lead or leads. Generally they are not portable and are usually installed in a panel or piece of equipment. They require physical connections to put them in series with the motor or apparatus being tested. These ammeters are usually more accurate than the clamp-on type and are used in motor control centers and pump panels.

A *MEGGER* is used for checking the insulation resistance on motors, feeders, buss bar systems, grounds, and branch circuit wiring.

WARNING

Turn off circuit breaker when using a megger.

There are three general types of meggers: crank-operated, battery-operated, and instrument. There are two leads to connect. One lead is clamped to a ground lead, and the other to the lead you are testing. The readings on the megger will range from "0" (ground) to Infinity (perfect), depending on the condition of your circuit.

The megger is usually connected on the motor terminals, one at a time, at the starter, and the other lead to the ground lead. Results of this test indicate if the insulation is deteriorating or cut.

If a low reading is obtained, disconnect motor leads from power or line leads. Meg motor and if low reading is observed, the motor winding insulation is breaking down. If a good reading is obtained, meg the circuit or branch wiring. If this reading is low, the wiring to the motor is bad. A rule of thumb to use is that you should not run a motor if it is less than one *MEGOHM*[3] per horsepower. This means a 5 horsepower motor should have a 5 megohm reading; 10 horsepower, a 10 megohm reading; 20 horsepower, 20 megohm reading; and so forth.

Motors and wirings should be megged at least once a year, and twice a year if possible. The readings taken should be recorded and plotted in some manner so that it can be determined when insulation is breaking down. Meg motors and wirings after a pump station has been flooded. If insulation is wet, excessive current could be drawn and cause pump motors to "kick out."

OHMMETERS, sometimes called circuit testers, are valuable tools used for checking electrical circuits. An ohmmeter is used only when the electrical circuit is *OFF*, or de-energized. The ohmmeter supplies its own power by using batteries. An ohmmeter is used to measure the resistance (ohms) in a circuit. These are most often used in testing the control circuit components such as coils, fuses, relays, resistors, and switches. They are used also to check for continuity. An ohmmeter has several scales which can be used. Typical scales are: R × 1, R × 10, R × 1,000, and R × 10,000. Each scale has a level of sensitivity for measuring different resistances. To use an ohmmeter, set the scale, start at the low point (R × 1), and put the two leads across the part of the circuit to be tested such as a coil or resistor and read the resistance in ohms. A reading of infinity would indicate an open circuit, and a "0" would read no resistance. These usually would be used only by skilled technicians because they are very delicate instruments.

All meters should be kept in good working order and calibrated periodically. They are very delicate, susceptible to damage, and should be well protected during transportation. When readings are taken, they should always be recorded on a machinery history card for future reference. Meters are a good way to determine pump and equipment performance. *NEVER USE A METER UNLESS QUALIFIED AND AUTHORIZED.*

---

[3] *Megohm. Meg means one million, so 5 megohms means 5 million ohms. A Megger reads in millions of ohms. Also see INSTRUCTION MANUAL FOR MEGGER INSULATION TESTERS, No. 21-J, published by Biddle Instruments, c/o Advertising Department, 510 Township Line Road, Blue Bell, Pennsylvania 19422. Also see Biddle's publication, A STITCH IN TIME, price $1.00.*

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 228.

9.23A How can you determine if there is voltage in a circuit?

9.23B What are some of the uses of a voltage tester?

9.23C What precautions should be taken before attempting to change fuses?

9.23D How do you test for voltage with a voltmeter when the voltage is unknown?

9.23E What could be the cause of amp readings different from the nameplate rating?

9.23F How often should motors and wirings be megged?

9.23G An ohm meter is used to check the ohms of resistance in what control circuit components?

9.24 ELECTRICAL SYSTEM EQUIPMENT

9.241 Need for Maintenance

Electrical system equipment is frequently the least understood and most neglected equipment in a lift station because it is not considered as a system which requires frequent inspection or maintenance; however, the reverse of this is actually true. Electrical equipment can be damaged more readily by operating conditions than almost any other kind of equipment. Water, dust, heat, cold, humidity, corrosive atmospheres, and vibration are all common lift station conditions that can affect the performance and the life of electrical equipment.

This section will discuss various elements in the electrical system of a lift station including motor control center components such as circuit breakers, contactors, protective devices, transformers and control relays. The section will also explain in detail important maintenance and operating aspects of the AC induction motor, the most common pump driver used in lift stations.

Electrical equipment should be inspected and maintained on at least an annual basis or more frequently depending on the equipment and the application. Inspection should include a thorough examination, replacement of worn and expendable parts, and operational checks and tests.

Listed below are examples of electrical equipment maintenance tasks. Check and inspect each of these items annually.

1. All switch gear and distribution equipment. Look for worn parts and note general condition.
2. Wiring integrity.
3. Terminal connections. Tighten if necessary (often needed with aluminum wire conductors).
4. Interlocking devices to prevent unauthorized entry.
5. Control circuits. Check operation and verify sequencing, including actual sequencing of pump motors as a function in wet well level.
6. All panel instruments. Clean and check for accuracy. Permanently installed, panel-mounted current and voltage meters can be added to existing electrical systems and should be specified on new projects. This eliminates the need for the operator to access the inside of the electrical system to obtain voltage/current readings and be exposed to hazardous voltages. Select a voltage meter that measures both phase-to-phase and phase-to-neutral voltage. Current meters should also allow switching to measure current in each of the three phases.
7. Mechanical disconnect switches. Service and lubricate all switches, fuses, disconnects, and transfer switches.
8. Fuses. Verify proper application, size and general condition. Check inventory of spare fuses.
9. Circuit breakers. Cycle each breaker and check for proper response and performance.
10. Contacts. Check for response (especially those in motor starters that carry high switching current); replace if necessary.
11. Enclosures. Clean and vacuum.

If these basic maintenance procedures are done at least annually, it will help minimize lift station electrical system failures including:

1. Current imbalances which ultimately result in motor failure,
2. Loose contacts or terminals in control and power circuits causing high-resistance contacts,
3. Overheating resulting in arcing, fire, and electrical system damage,
4. Dirty enclosures and components which allow a conductive path to build up between incoming phases causing phase-to-phase shorts, and
5. Corrosion that causes high-resistance contacts and heating.

9.242 Equipment Protective Devices

Electricity, by its very nature, is extremely hazardous and safety devices are needed to protect operators and equipment. Water systems have pressure valves, pop offs and different safety equipment to protect the pipes and equipment. So must electricity have safety devices to contain the voltage and amperage that comes in contact with the wiring and equipment.

Lift station electrical equipment protective devices may consist of fuses, circuit breakers, and motor and circuit overload devices. These devices usually are found in combination so that all three are present. For example, a fused disconnect switch (see Figure 9.6) may protect the entire electrical distribution system within the lift station; circuit breakers may be used to protect branch motor circuits from short circuits; and a motor starter with overload elements would be installed to protect the motor from motor overloads.

Regardless of which type of protective device you are working with, if it "blows" or trips, the potential source of the problem should be investigated and identified. All too frequently, a fuse is simply replaced or a circuit breaker simply reset without any investigation into the problem. If the protective device has operated reliably for long periods of time (for example, no nuisance tripping), then tripping is almost a sure indication that a problem exists somewhere in the circuit and the device is trying to protect the circuit. Resetting the circuit breaker or replacing a fuse, and then restarting the system may result in damage or more severe damage to the equipment that is being protected.

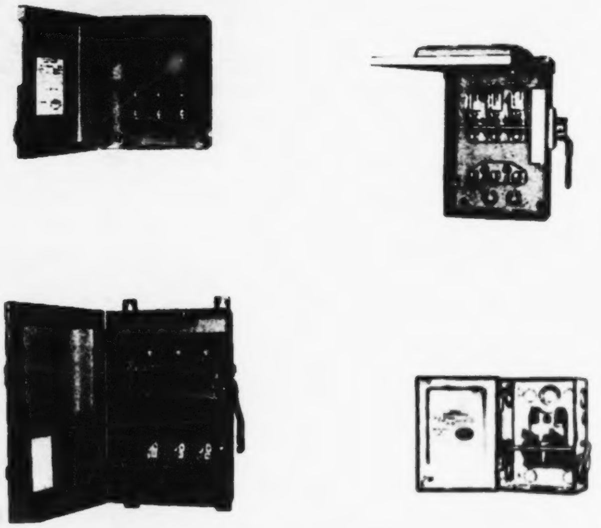


Fig. 9.6 Fused disconnect switches
(Courtesy of Consolidated Electrical Distributors, Inc.)

Once again, if you are not qualified to perform electrical troubleshooting, you should not attempt to proceed any further than providing diagnostic analysis. Maintenance must always be performed by trained personnel. It does not take high voltage or extreme currents to seriously injure an operator or cause a fatality.

9.243 Fuses (Figure 9.7)

The power company installs fuses on their power poles to protect their equipment from damage. We also must install something to protect the main control panel and wiring from damage due to excessive voltage or amperage.

A FUSE is a protective device having a strip or wire of fusible metal which, when placed in a circuit, will melt and break the electrical circuit when subjected to an excessive temperature. This temperature will develop in the fuse when a current flows through the fuse in excess of what the circuit will carry safely. This means that the fuse must be capable of de-energizing the circuit before any damage is done to the wiring it is safely protecting. Fuses are used to protect operators, main circuits, branch circuits, heaters, motors, and various other electrical equipment.

There are several types of fuses, each being used for a certain type of protection. Some of these are:

1. *CURRENT-LIMITING FUSES:* Used to protect against current in circuits.
2. *DUAL-ELEMENT FUSES:* Used for motor protection.
3. *TIME-DELAY FUSES:* Used in electronic and motor starting circuits.
4. *SAND-FILLED FUSES:* Used on high voltage.
5. *PHASE FUSES:* Used to protect phase sequence.
6. *VOLTAGE-SENSITIVE FUSES:* Used where close voltage control is needed.

Since fuses are one-time-use devices, little can be done to check them during maintenance procedures; however, the following tasks should be performed at least annually:

1. Inspect bolted connections at the fuse clip or fuse holder for signs of looseness,
2. Check connections for any evidence of corrosion from moisture or atmosphere (air pollution),
3. Tighten connections,
4. Check fuse for obvious overheating,
5. Inspect insulation on the conductors coming into the fuses on the line side and out of the fuses on the load side for evidence of discoloration or bubbling which would indicate overheating of the conductors.

Definition Line Side/Load Side

Line side/Load side are terms frequently used to describe the incoming and outgoing conductors of circuit breakers, motor starters, and other devices. The line side of the device is where incoming power is fed into the device. The load side is the terminal where power is fed to the load, for example, a motor.

Usually when a fuse blows it is not visually evident and it is necessary to check it with a meter. The following procedure should be followed to determine whether or not a fuse has blown:

1. Ensure the main disconnect or circuit breaker is in the off position and locked out;
2. Check for live voltage in the panel (power may feed into a control system from other sources);
3. Remove fuse with a fuse-pulling device;
4. Test resistance of fuse using an ohmmeter (an open circuit [infinite resistance] indicates a blown fuse, whereas, a short circuit indicates a good fuse); and
5. Only in the event it is not possible to disconnect incoming power should the fuse be checked with power applied. In this case the procedure as outlined in Section 9.23, "Tools, Meters and Testers" may be used.

9.244 Circuit Breakers (Figure 9.8)

Circuit breakers are used as disconnecting devices and to protect electrical systems primarily from short-circuit conditions which may occur on the load side of the circuit breaker. In some cases, circuit breakers can also be used in conjunction with motor starters to provide motor overload protection. In most cases, however, they are sized to protect the entire system as opposed to specific components in the circuit from short-circuit fault currents.

Molded-Case Circuit Breakers

Lift station motor control center circuit breakers are typically housed in a molded case unless the motor and/or other electrical equipment is high horsepower. Molded-case circuit breakers can be thermal-magnetic trip or magnetic only.

Thermal-magnetic trip circuit breakers provide both overload protection and short-circuit protection. If the circuit is overloaded, a thermal sensing element will detect this and cause the circuit breaker to open (or "trip"). In addition, the magnetic sensing element of the circuit breaker rapidly senses extremely high currents which flow under a short-circuit condition and will also trip the circuit breaker.

The amount of current that can flow during a short-circuit condition is a function of many things. For this reason, circuit breaker replacement should be done very carefully and by

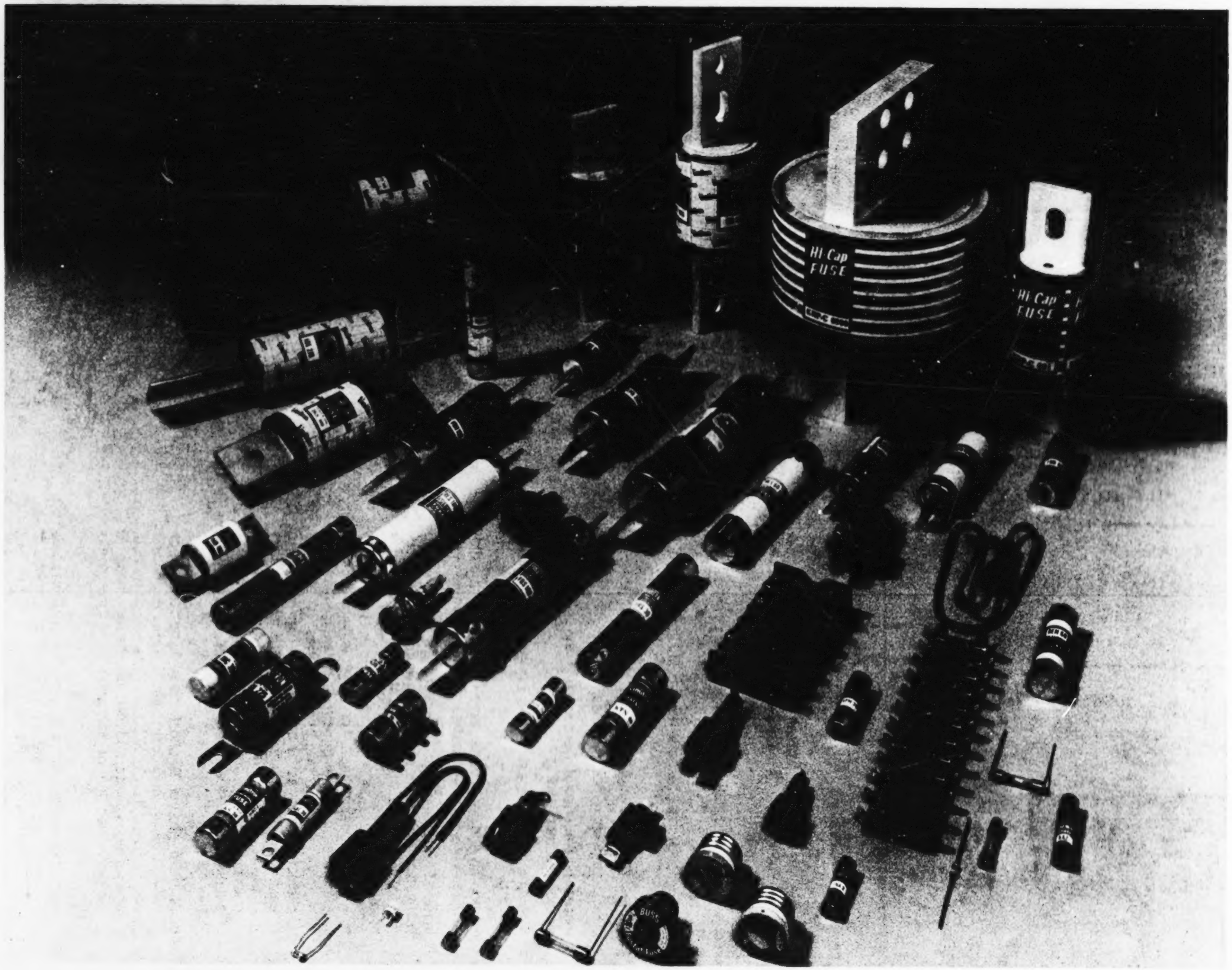

HI-Cap
FUSE
HI-Cap
FUSE
BUSS

Fig. 9.7 Fuses

(Courtesy of Bussmann Manufacturing, McGraw-Edison Company Division)

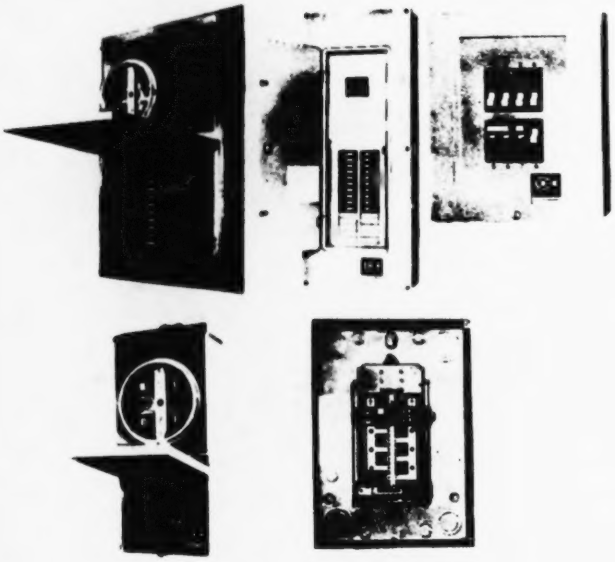


Fig. 9.8 Circuit breakers

(Courtesy of Consolidated Electrical Distributors, Inc.)

personnel who are qualified to evaluate circuit characteristics.

Molded-case circuit breakers require little maintenance other than:

1. Manually trip and operate the mechanism,
2. Check connections for tightness,
3. Inspect for evidence of overheating on the line and load side conductors, and
4. Inspect the circuit breaker case for evidence of overheating.

The following additional tests can be performed on molded-case circuit breakers, but require specialized equipment.

1. Insulation resistance test. This test uses a high voltage DC megger device (described previously in this chapter) to check the internal resistance of the circuit breaker.
   a. Phase-to-phase check. Apply high voltage between the three phases of the circuit breaker, which ultimately could lead to a phase-to-phase short. This check is performed by applying the high voltage to each combination of two phases of the three phases (1 and 2, 1 and 3, and 2 and 3) one at a time. At least one meg ohm of resistance in the insulation is adequate. If the insulation resistance is inadequate, this could lead to a phase-to-phase short.
   b. Phase-to-ground. To check the insulation resistance between each individual phase to ground, connect one phase on the circuit breaker at a time to ground, apply a high voltage, and measure the resistance. At least one meg ohm of resistance in the insulation is desirable.
2. Contact resistances. With a DC power supply, measure the voltage drop from the line side to the load side of the circuit breaker with the circuit breaker closed, but power disconnected. An excessive voltage drop indicates a high-resistance condition between the contacts, and the circuit breaker must be replaced.
3. Overload trip test. This test requires a specialized circuit breaker tester that is capable of generating currents in the range of the trip devices of the circuit breaker. Connect the test device between the line and the load and run a current equal to the circuit breaker capacity through the circuit breaker. A current in the range of the trip devices that causes them to trip will indicate that the circuit breaker is functioning properly.

Because the interior components of molded-case circuit breakers are not accessible, repair or replacement of internal parts is not possible. The entire circuit breaker must be replaced when it fails.

Motor Protection Devices

Since circuit breakers are normally used as a disconnecting device and as a protective device for the entire circuit, including the conductors that are connected to the breaker, the circuit breaker must be sized for the current carrying capacity of all components or equipment connected to it. For example, a thermal-magnetic circuit breaker must have a continuous current rating of at least 115 percent of motor full-load amps and the rating may be as great as 250 percent. This means that the thermal overload-sensing device will not trip the breaker unless there is 115 percent overload present. In most cases, by the time this occurs, the motor will have been seriously damaged.

To overcome this problem and to provide further protection for motors, a device called a motor starter is usually installed in lift station motor control centers. The device operates through the supervisory control system responding automatically to the level in the wet well. A typical configuration is referred to as a magnetic motor starter and can be operated manually as well as automatically. Section 9.35 of this chapter contains a complete discussion of motor starters.

Figure 8.21 (page 41) illustrates a typical air bubbler control system. Output from the transducer passes through a relay logic system to the magnetic starter, turning the starter on and off.

NEVER INCREASE THE RATING OF THE OVERLOAD HEATERS BECAUSE OF TRIPPING. YOU SHOULD FIND THE PROBLEM AND REPAIR IT. There are many other protective devices for electricity such as motor winding thermostats, phase protectors, low voltage protectors, and ground fault protectors. Each has its own special applications and should never be tampered with or jumped.

9.245 Ground

GROUND is an expression representing an electrical connection to earth or a large conductor which is at the earth's potential or neutral voltage. Motor frames and all electrical tools and equipment enclosures should be connected to ground. This is generally referred to simply as grounding, or equipment ground.

Connecting motor frames, tools and electrical equipment to ground is a safety precaution which protects *YOU* and the motors, tools and equipment. If one of the conductors opens up and is not connected to ground, then *YOU* become the ground, the current could flow through *YOU* and *YOU* could receive a severe or fatal electrical shock. If the current flows through motors, tools or equipment, severe damage could occur.

The third prong on cords from electric hand tools is the equipment ground and must never be removed. When an adapter is used with a two-prong receptacle, the green wire on the adapter should be connected under the center screw on the receptacle cover plate. Many times equipment grounding, especially at home, is achieved by connecting onto a water pipe or drain rather than a rod driven into the ground. This practice generally is not recommended when plastic pipes and other non-conducting pipe materials are used unless it is known that the piping is all metal and not interrupted. Also corrosion can be accelerated if pipes of different metals are used. A rod driven into dry ground isn't very effective as a ground.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 228.

9.24A What are two types of safety devices found in main electrical panels or control units?

9.24B What are fuses used to protect?

9.24C Why must a fuse never be by-passed or jumped?

9.24D How does a circuit breaker work?

9.24E What is the most common pump driver used in lift stations?

9.24F Basic lift station maintenance procedures performed at least annually will help minimize what types of lift station failures?

9.24G What should be done when a fuse or circuit breaker "blows" or trips?

9.24H What types of annual maintenance should be performed with regard to fuses?

9.25 Motor Control/Supervisory Control and Electrical System

The motor and supervisory control systems are composed of the auxiliary electrical equipment such as relays, transformers, lighting panels, pump control logic, alarms, and other equipment typically found in a lift station electrical system over and above the protective devices and the motor starters.

In general, annual maintenance should be performed on all these systems as follows:

1. Control Transformers
   a. Check primary, secondary, and ground connections
   b. Check for loose windings/coils
   c. Inspect insulation for signs of overheating as a result of overloading
   d. Check mounting for tightness
   e. Check primary/secondary fusing and fuse clips for tightness
2. Motor Control Centers
   a. Check panel lights for operation
   b. Check control knobs/switches for freedom of movement and contact condition
   c. Check horizontal and vertical bus and supports for evidence of heating or arcing and tighten. (Bus refers to the copper or aluminum bars that run horizontally and vertically in the motor control center; they feed the three-phase power to the branch circuits.)
3. Control Relays
   a. Check mounting for looseness
   b. Tighten all screw terminal connections
   c. Check for evidence of overheating or arcing indicated by carbon buildup or discoloration of plastic housing
4. Clean and vacuum enclosure

NOTE: It is appropriate to discuss the use of aluminum wire as a conductor. This has become very common over the last few years because of its economic advantage over copper. Copper traditionally has been used for virtually all wiring applications in wastewater lift stations including the conductors feeding the station from the utility transformers, bus bar, motor control centers, control wiring, as well as power wiring to motors.

The greatest advantage of copper is that it oxidizes very slowly. Even though this reaction with air or moisture results in a surface layer of impurities, the surface is soft and is easily penetrated by the connecting device. With the exception of the annual tightening of the terminals, copper requires very little maintenance.

Aluminum is much softer and reacts much more rapidly with the air so aluminum begins oxidizing almost immediately when exposed to air. This oxide, as opposed to that found on copper, tends to form an insulating layer over the aluminum wire. Aluminum also expands and contracts 36 percent more than copper, which will result in loose connections, high resistance contacts, heat formation, and failure of the connection. When using aluminum conductors the following rules must be observed:

1. The connecting terminal must be specifically designed to accommodate aluminum conductors (connectors that are rated for this use are stamped with the letters CU/AL indicating that they are suitable for use with copper (CU) or aluminum (AL) conductors), and
2. The termination point of the aluminum conductor must be coated with a compound to prevent the formation of the insulating oxides and should be wire-pressure scraped before the compound is applied.

Because of these limitations, aluminum conductors and bus bars should be inspected and maintained more frequently than the traditional copper conductors. Conduct a visual inspection of the terminal, conductor, and insulation for any evidence of discoloration and overheating.

Three basic factors contribute to the reliable operation of electrical systems found in lift stations. They are:

1. An adequate preventive maintenance program must be implemented,
2. A knowledge of the system by the collection system operator, even though the operator does not perform the actual maintenance, and
3. KEEP IT CLEAN!
   KEEP IT DRY!
   KEEP IT TIGHT!

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 228.

9.25A Motor and supervisory control systems are composed of what types of auxiliary electrical equipment?

9.25B What are the three basic factors that contribute to the reliable operation of electrical systems found in lift stations?

9.3 MOTORS

9.31 Types

Electric motors are the machines most commonly used to convert electrical energy into mechanical energy. Although a multitude of different types of motors are produced today, the most common pump motor is the AC (Alternating Current) induction motor.

Two types of induction motor construction are typically encountered when dealing with AC induction motors:

1. Squirrel Cage Induction Motor (SCIM, by far the most numerous), and
2. Wound Rotor Induction Motor (WRIM, used for variable-speed applications.

Figure 9.9 illustrates a horizontal squirrel cage induction motor with a drip-proof enclosure. Major components of the motor are:

1. Stator winding with connection to the three-phase power supply,
2. Shaft end and opposite end ball bearings,
3. Rotor assembly including rotor, shaft, and fans on the rotor cage, and
4. Enclosure.

Stator construction is generally the same in both types of motors. The primary difference is that the squirrel cage induction motor has no electrical connections to the rotor circuit. In contrast, a wound rotor motor has a slip ring assembly and brushes that connect the rotor circuit to an external electrical circuit. This arrangement varies the resistance, thus causing the speed characteristics of the wound rotor motor to change. Therefore, a wound rotor is usually found in a variable-speed pump station application. This section will deal specifically with the squirrel cage induction motor since this is the type you will most often encounter.

9.32 Nameplate Data (Figure 9.10)

As part of your preventive maintenance program, record the motor nameplate information in the file for each motor or piece of equipment as recommended in NEMA (National Electrical Manufacturers Association) publication MG1, Section 10.3A.

Listed below is a brief description of the information you will find on the nameplate and how it relates to motor performance.

Serial Number. This is a unique number assigned by the manufacturer based on the manufacturer's numbering system to identify that specific motor. (This number should be available and used whenever it is necessary to communicate with the manufacturer.)

Type. This may be a combination of letters and numbers, established by the manufacturer to identify the type of enclosure and any modifications to it.

Model Number. The manufacturer's model number.

Horsepower. Rated horsepower is the horsepower that the motor is designed to produce at the shaft when power is applied at the rated frequency and voltage and the motor is operating at a service factor of 1.0.

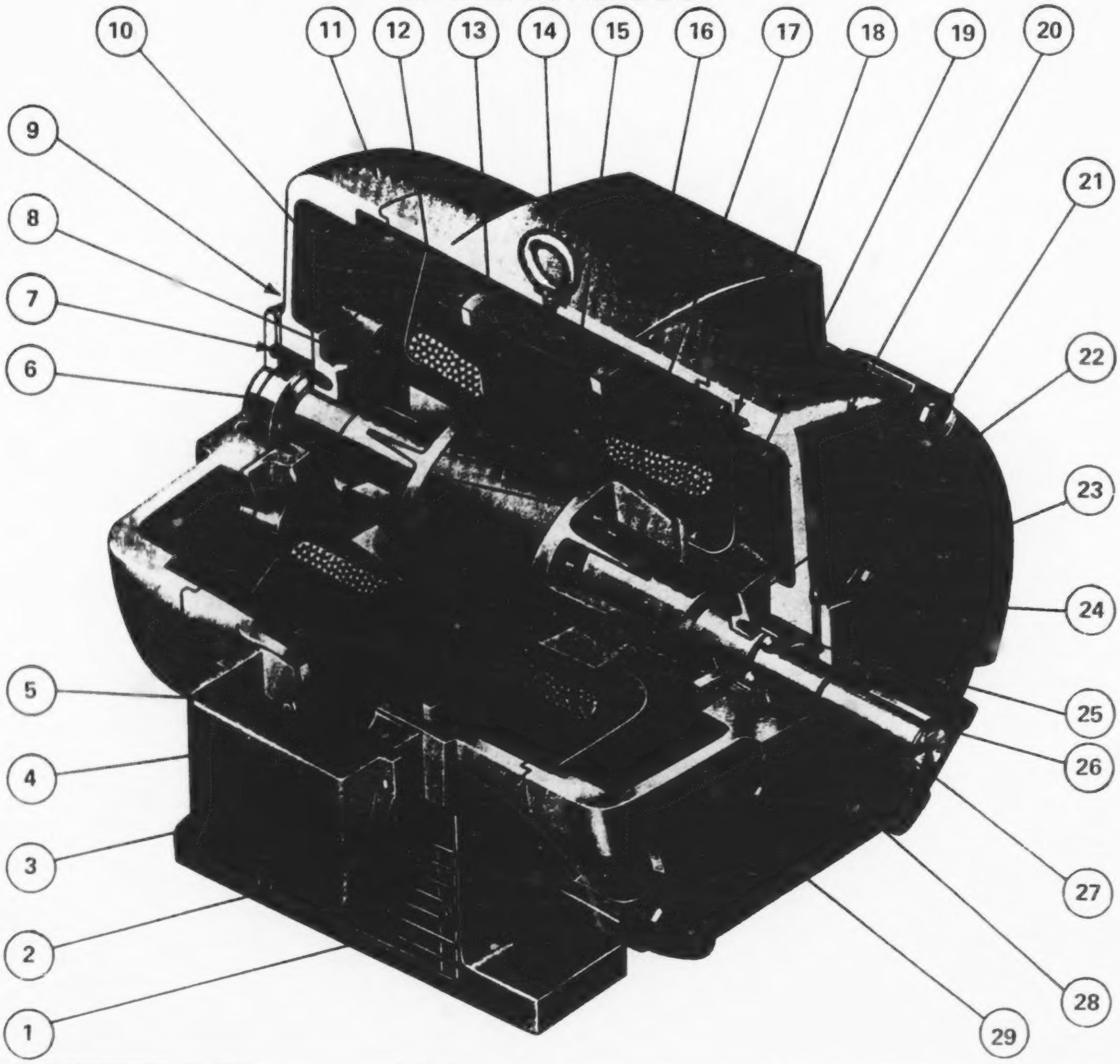
Frame. This identifies the frame size in accordance with established NEMA Standards and does not vary from manufacturer to manufacturer. Therefore, the motor from one manufacturer with a NEMA frame is dimensionally identical to that same frame size from another manufacturer.

Service Factor. Service factors of 1.0 and 1.15 are commonly found on pump station motors. A service factor of 1.0 indicates that the motor may be run continuously at its rated horsepower without causing damage to the insulation system. A 1.15 service factor indicates that the motor may occasionally be run at a horsepower equal to the rated horsepower times the service factor without serious injury to the insulation system. This allows for intermittent variations in voltage which will cause internal heating on the motor windings. A service factor above 1.0 should never be relied upon to accommodate continuous loads because such use will quickly degrade the insulation system.

Amps. The current drawn by the motor at rated voltage and frequency at rated horsepower.

Volts. This is the voltage that would be measured at the terminals of the motor as opposed to the voltage of the supply.

TYPICAL CUTAWAY VIEW
OF A MARATHON DESIGNED, DRIPPROOF, HORIZONTAL
INTEGRAL HORSEPOWER MOTOR & PARTS DESCRIPTION
364 THRU 445 FRAME SIZE



ITEM	DESCRIPTION	ITEM	DESCRIPTION	ITEM	DESCRIPTION
1.	•• Frame Vent Screen	11.	Bracket O.P.E.	21.	Bracket Holding Bolt
2.	Conduit Box Bottom	12.	Baffle Plate O.P.E.	22.	Inner Bearing Cap P.E.
3.	Conduit Box Top-Holding Screw	13.	Rotor Core	23.	Inner Bearing Cap Bolt
4.	Conduit Box Top	14.	Lifting Eye Bolt	24.	Grease Plug
5.	Conduit Box Bottom-Holding Bolt	15.	Stator Core	25.	*Ball Bearing P.E.
6.	*Ball Bearing O.P.E.	16.	Frame	26.	Shaft Extention Key
7.	Pre-loading Spring	17.	Stator Winding	27.	Shaft
8.	Inner Bearing Cap O.P.E.	18.	Baffel Plate Holding Screw	28.	Drain Plug (grease)
9.	Grease Plug	19.	Baffle Plate P.E.	29.	•• Bracket Screen
10.	Inner Bearing Cap Bolt	20.	Bracket P.E.		

P.E. = Pulley End

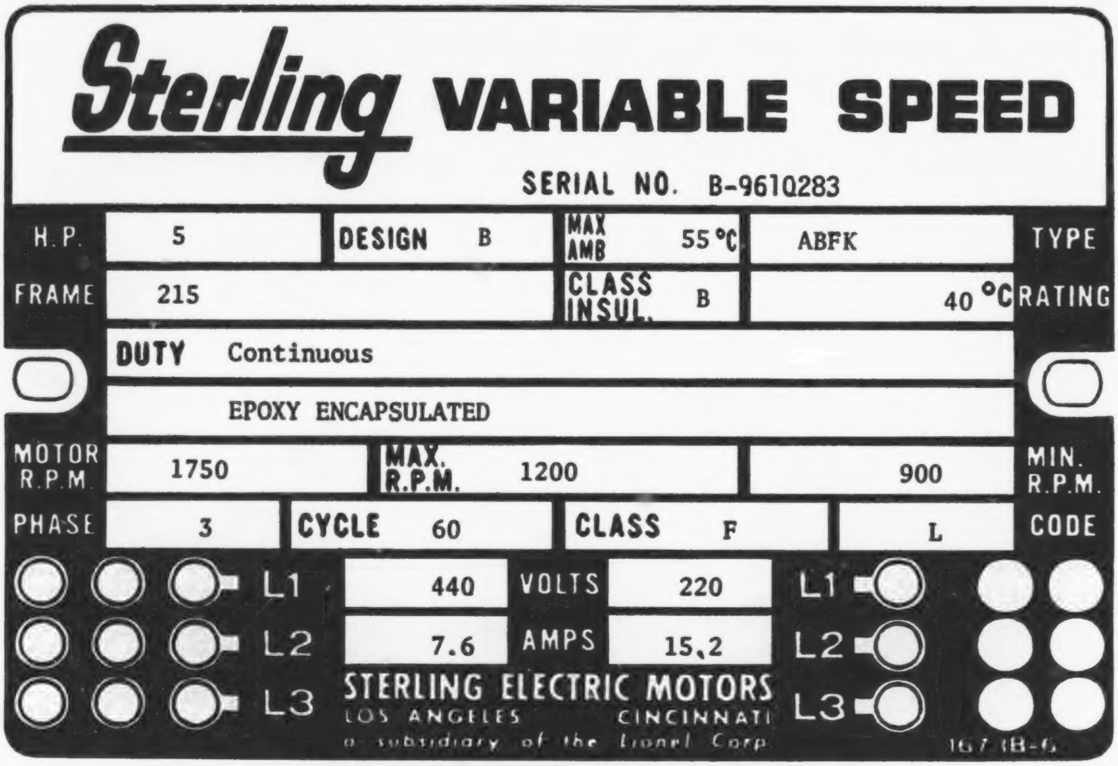
O.P.E. = Opposite Pulley End

* = Bearing Numbers are shown on motor nameplate when requesting information or parts always give complete motor description, model and serial numbers.

** = Bracket and frame screens are optional.

Fig. 9.9 Horizontal squirrel cage induction motor

(Courtesy of Marathon Electric)



Sterling VARIABLE SPEED

SERIAL NO. B-9610283

H.P.	5	DESIGN B	MAX AMB 55 °C	ABFK	TYPE
FRAME	215		CLASS INSUL. B	40 °C	RATING
	DUTY Continuous				
	EPOXY ENCAPSULATED				
MOTOR R.P.M.	1750	MAX. R.P.M. 1200		900	MIN. R.P.M.
PHASE	3	CYCLE 60	CLASS F	L	CODE

L1	440	VOLTS	220	L1
L2	7.6	AMPS	15.2	L2
L3				L3

STERLING ELECTRIC MOTORS
LOS ANGELES CINCINNATI
a subsidiary of the Lionel Corp.

167 1B-6

NOTE: 1. The motor for this unit is rated at 1750 RPM and the maximum speed for the variable drive unit is 1200 RPM.

2. The 40°C rating is the allowable operating temperate above ambient temperature.

Fig. 9.10 *Typical nameplate*
(Courtesy of Sterling Power Systems, Inc.)

AMPS
FRAME
SERVICE FACTOR
DUTY
PHASE
RPM
HORSEPOWER
AMBIENT TEMPERATURE
BEARINGS
DESIGN
CLASS OF INSULATION

Class of Insulation. Various classes of insulation material (described below) are available and the listed class will determine the operating temperatures at which the motor can safely operate.

RPM. Speed of the motor shaft, in revolutions per minute, at rated horsepower with rated voltage and frequency being supplied.

Hertz. Frequency, in cycles per second, of the utility company power.

Duty. Normally stamped "continuous" which means the motor can operate 24 hours a day, 365 days a year. In some cases, the motor nameplate will indicate "intermittent duty" for a specified time interval. This means the motor can operate at full load for the time interval specified, and then must be shut down and allowed to cool before restarting.

Ambient Temperature. Specifies the maximum ambient (surrounding) temperature at which the motor can safely operate. If the ambient temperature is exceeded, a corresponding increase of operating temperatures in the winding will degrade the insulation system and cause premature failure of the motor.

Phase. This indicates the number of phases; for example, 3 or three-phase which indicates the phase for which the motor is designed.

KVA Code. Starting inrush current which relates KiloVolt Amps to HorsePower (KVA/HP).

Design. This letter indicates the electrical design characteristics, and therefore, torque, speeds, inrush current, and slip values (these values and codes are also specified by NEMA).

Bearings. This number and letter sequence is designated by the Anti- Friction Bearing Manufacturers' Association Standards (AFBMA). It specifies looseness of the bearing fit, type of retainer, degree of protection, and dimension of the bearings. In most cases, unless the bearing is an extremely specialized type, the standard allows the use of bearings of different manufacturers.

Efficiency. This indicates the nominal operating efficiency of the motor at full load (Power Out/Power In)(100%).

9.33 Causes of Failure

Over the years, a considerable amount of research has been (and continues to be) conducted by various associations and manufacturers of electrical equipment to identify types of motor failures and the reasons for failures in AC induction motors. This section will deal with some of the common causes of motor failure and will suggest what you can do to minimize motor failures in lift stations.

In a survey of 9,000 motor failures by the Electrical Research Association, Letterhead, England, the following causes and percentages of motor failures were identified:

Causes of Motor Malfunction	Frequency, %
1. Overload (Thermal)	30
2. Contaminants	19
3. Single phasing	14
4. Bearing failures	13
5. Old age	10
6. Miscellaneous	9
7. Rotor failures	5

A study conducted by the Dymac Division of Scientific Atlanta identifies the frequency with which specific components failed.

Failed Component	Frequency, %
1. Stator windings	70
2. Rotor windings	10
3. Bearings	10
4. Other	10

This information suggests that a large percentage of motor failures could be prevented. Sixty-three percent of the failures examined were primarily due to overload, single phasing, and contaminants, and all of these factors can be controlled by the operator. In addition, since 70 percent of the failures occur in the stator, we can assume that many of the failures are related to the insulation system used to protect the motor stator windings. For this reason, the next section will focus on the motor insulation system and show how a variety of conditions can lead to excessive heat buildup that will eventually result in motor failure.

9.34 Insulation

9.341 Types and Specifications

Four classes or levels of insulation systems are available:

1. Class A,
2. Class B,
3. Class F, and
4. Class H.

Each class of insulation is defined by the temperature limitation of the insulation itself. If the temperature limitation is exceeded, the insulation will deteriorate and, ultimately, cause a premature motor failure. The temperature rating consists of three components:

1. Ambient operating temperature—the air temperature where the motor is operating; for example, air temperature inside the lift station;
2. Temperature rise—the maximum inside temperature of the windings during normal operation; and
3. Hot-spot allowance—because of inconsistencies in the manufacturing process and the winding materials, a 10° C hot-spot allowance is included.

Older motors, those over 20 to 25 years old, are likely to have Class A insulation systems. A standard motor today has a Class B system or, in some cases, Class F. In extreme environments, a Class H insulation system may be used.

Table 9.1, AC Motor Temperature Limits, lists the temperature limitations for the four classes of insulation as they relate to the type of motor construction. For example, for all motors with a 1.15 or higher service factor, the total temperature that the insulation can withstand is 140° C for Class B insulation, or 165° C with Class F insulation. Table 9.2 lists typical materials used for motor insulation.

9.342 Causes of Failure

Obviously, induction motors are a critical and integral part of the operating ability, efficiency, and reliability of the lift station. When failures occur they can be extremely serious because the loss of pumping capacity creates critical operating problems. In addition, repair or replacement of a motor is an expensive, labor-intensive job.

If a motor is operated in a clean/dry environment and within its specified nameplate load and operating characteristics, there is no reason why the motor should not operate for years and years without major maintenance. Unfortunately, a number of different factors can cause a motor to operate outside its specified ranges. When this occurs, the life of the motor is shortened significantly.

In the discussion that follows, these conditions will be addressed in terms of problems/solutions. You will see that, in one way or another, failure to adhere to motor nameplate guidelines frequently results in excessive heat buildup, damaged motor insulation, and eventual motor failure.

1. *PROBLEM:* Contaminants. Insulation failure can occur when deposits of dust, grease, or other foreign material accumulate on the windings and prevent the dissipation of the heat generated in the motor winding during normal operation. This causes local hot spots in the winding and,

TABLE 9.1 AC MOTOR TEMPERATURE LIMITS[a]

	Temperature (Deg. C)				
	Class A		Class B	Class F	Class H
1.0 Service Factor					
Drip-proof					
Ambient Temperature	40	40	40	40	40
Rise by Thermometer	40	..	..	..	..
Rise by Resistance	..	50	80	105	125
Service-Factor Margin	10	10	..	..	..
Hot-Spot Allowance	15	5	10	10	15
Total Temperature	105	105	130	155	180
TEFC					
Ambient Temperature	40	40	40	40	40
Rise by Thermometer	55	..	..	..	..
Rise by Resistance	..	60	80	105	125
Hot-Spot Allowance	10	5	10	10	15
Total Temperature	105	105	130	155	180
TENV[b]					
Ambient Temperature	40	40	40	40	40
Rise by Thermometer	55	..	85	..	..
Rise by Resistance	..	65	..	110	135
Hot-Spot Allowance	10	0	5	5	5
Total Temperature	105	105	130	155	180
Encapsulated[c]					
Ambient Temperature				40	40
Rise by Resistance				85	110
Hot-Spot Allowance				5	5
Total Temperature				130	155
1.15 or Higher Service Factor					
All Motors					
Ambient Temperature				40	40
Rise by Resistance[d]				90	115
Hot-Spot Allowance				10	10
Total Temperature				140	165

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[a] Adapted from National Electrical Manufacturers Association (NEMA) publication MG 1-12.39 and 12.40.

[b] Including all fractional-horsepower totally enclosed motors and fractional-horsepower motors smaller than frame 42.

[c] Enclosed.

[d] At service-factor load.

TABLE 9.2 INSULATION MATERIALS

	Class A Systems-103C	Class B Systems-130C	Class F Systems-155C	Class H Systems-180C
Varnish	Modified phenolic Modified asphalt Alkyd polyester	Unmodified polyester Epoxy Modified phenolic	Modified polyester Epoxy	Silicone Polyimide
Wire Insulation	Vinyl acetal enameled	Modified polyester enameled Epoxy enameled Enamel plug glass yarn	Modified polyester enameled Epoxy enameled	Glass yarn, silicone varnish covered Polyimide
Other	Rag paper Kraft paper Polyester film Acetate film Varnished cambric Wood Fiber Cotton cord	Polyester film Polyester mat Varnished glass Mica flake or mica paper Polyester glass Laminated glass Asbestos Melamine Glass cord	Varnished glass Laminated glass Mica Flake or mica paper Glass cord Polyester glass Tetrafluoroethylene resin	Glass cord Mica flake or mica paper Silicone varnished glass Laminated glass Polyimide film Polyimide varnished glass Polyimide filament

when the insulation breaks down completely, it will cause a phase-to-phase short characterized by arcing and melting between the phases' windings.

Vertical motors are susceptible to improper greasing methods and materials. Frequently, grease escapes from the bearing and the bearing housing and then contaminates the upper end turns on the stator winding, resulting in winding failure.

1. *SOLUTION:* Keep motors clean and free of dirt or grease accumulations. Follow the manufacturer's recommended methods and materials for greasing the equipment.

2. *PROBLEM:* Short cylcing or excessive starts. Short cycling occurs when the automatic control system triggers frequent starts and stops of the pump and motor in response to fluctuating wet well elevations or because of a failure in the control system.

When induction motors start, the current (called locked rotor amps) required to magnetize the windings and start the rotor can be five to eight times the normal running current. For example, with a motor rated at 100 amps for full-load current, the starting sequence will require anywhere from 500 to 800 amps to start the motor rotating.

When frequent starts occur, the heat generated by the locked rotor currents never has a chance to dissipate and the internal winding temperature increases with each successive start of the motor. Typically, motors up to 100 horsepower should not exceed more than four or five starts per hour and as the horsepower increases, motor starting limitations may reduce the number to as few as one start per hour.

2. *SOLUTION:* To overcome excessive heat buildup from frequent starts and stops of a motor, use a reduced-voltage method of starting the motor. Table 9.3 compares different reduced-voltage starting methods.

TABLE 9.3 REDUCED-VOLTAGE STARTING[a]

TYPE OF STARTING	RELATIVE STARTING CURRENT	RELATIVE STARTING TORQUE
1. Across-the-line	100%	100%
2. Resistors/reactor (at 65% voltage)	65%	65%
3. Auto Transformer (at 65% voltage)	42%	42%
4. W Delta Winding	33%	33%
5. Two-Part Winding	50%	50%

---

[a] Compared with full-voltage, across-the-line starting which typically draws 6.5 times the full-load current.

3. *PROBLEM:* High ambient operating temperature. If the ambient operating temperature exceeds that specified on the nameplate, it will contribute to a higher internal operating temperature. For all classes of insulation, the maximum ambient temperature is specified as 40° C (approximately 104° F).

3. *SOLUTION:* Provide adequate ventilation in lift stations and outdoor motor installations, particularly in southern climates where temperatures can be expected to exceed 104° F.

4. *PROBLEM:* Obstructed enclosure vents. All motor enclosures are designed for maximum dissipation of internally generated heat.

4. *SOLUTION:* In open, drip-proof motors, do not allow obstructions of the ventilation openings. Similarly, in totally enclosed, fan-cooled motors, a buildup of dirt, grease, or dust on the ribs of the enclosure will decrease the ability of the enclosure to dissipate heat. Keep the enclosure clean.

In outside installations, construct the enclosure to prevent entry by rodents. Frequently check rodent screens, if present, to ensure they are not clogged with foreign material. In areas of high humidity, treat the enclosure with an anti-fungicide to prevent formation of fungus on the insulation surface.

5. *PROBLEM:* Single phasing. Single phasing refers to the condition that occurs when one phase of the power source to the motor is lost, either from the utility company or from a fuse blowing in one phase in the motor control center. Under a single-phase condition, an induction motor which is already rotating will continue to rotate; however, it will be characterized by increased noise and vibration. If the motor is not rotating, a single-phase condition will not start the motor, will cause excessive noise and vibration, and will continue to do so until the protective device senses the condition and trips the overloads. Single-phase condition causes unbalanced currents to circulate in the rotor causing increases in internal motor heating.

5. *SOLUTION:* To correct a single phasing problem, determine why one phase is missing. Did the utility company lose a phase (a common problem) or is a fuse blown or a circuit breaker tripped in the motor control center. Once the source of the problem is identified, then it can be corrected by notifying the utility company, replacing the blown fuse, or resetting the tripped circuit breaker.

6. *PROBLEM:* Motor overloading. This is operation of the motor in a way that causes it to draw current in excess of the motor nameplate current. Overloading can happen inadvertently through improper operation on the pump curve by changing impeller diameters or through a change in the dynamic operating conditions of the pump which changes the total dynamic head (TDH).

Other conditions that can cause motor overloading include bearing problems and jamming of material between the rotating impeller and the stationary pump housing. More energy is required to operate the pump when rags, rocks or timbers interfere with free rotation of the impeller.

6. *SOLUTION*: A thorough understanding of hydraulics and the existing operating conditions is required before changes in the pump can be made since improper changes can have disastrous effects on the motor. Know what you are doing before making any changes.

7. *PROBLEM*: Voltage imbalance. A common problem found in lift stations with a high rate of motor failure is voltage imbalance or unbalance. Unlike a single-phase condition, all three phases are present but the phase-to-phase voltage is not equal in each phase.

Voltage imbalance can occur in either the utility side or the lift station electrical system. For example, the utility company may have large single-phase loads (such as residential services) which reduce the voltage on a single phase. This same condition can occur in the pump station if a large number of 120/220 volt loads are present. Slight differences in voltage can cause disproportional current imbalance; this may be six to ten times as large as the voltage imbalance. For example, a two percent voltage imbalance can result in a 20 percent current imbalance. A 4.5 percent voltage imbalance will reduce the insulation life to 50 percent of the normal life. This is the reason a dependable voltage supply at the motor terminals is critical. Even relatively slight variations can greatly increase the motor operating temperatures and burn out the insulation.

Loose connections will also cause voltage imbalance as will high-resistance contacts, circuit breakers, or motor starters.

7. *SOLUTION*: Motor connections at the circuit box should be checked frequently (semi-annually or annually) to ensure that the connections are tight and that vibration has not rubbed through the insulation on the conductors. Measure the voltage at the motor terminals and calculate the percentage imbalance (if any) using the formula below.

CALCULATING PERCENT VOLTAGE IMBALANCE

a. To calculate the percent of voltage imbalance, measure the voltage in each phase; add the three voltages and divide by 3 to get the average voltage (for example, 201 + 212 + 208 = 621 ÷ 3 = 207).

b. Find the maximum deviation. This is the greatest amount by which one of the voltages varies from the average. To find this number, make two calculations:

> Subtract the lowest voltage from the average voltage:
> 207 − 201 = 6 and
> Subtract the average voltage from highest voltage:
> 212 − 207 = 5.

The larger of the two results is the maximum deviation (6).

c. Divide the maximum deviation by the average voltage and multiply by 100% (6 ÷ 207 × 100% = 2.9%). The voltage imbalance is 2.9%.

Internal thermal protection devices are another form of motor and insulation protection. Such devices are especially desirable on motors that are likely to experience occasional overload conditions or voltage imbalances. Thermal protection devices may include the following features:

1. Built-in thermal switches which automatically open when the motor overheats. This type of device will not reset until the motor cools, at which time, the switch resets automatically. (In some cases, there may be a reset button on the motor enclosure.) This type of protection is normally limited to small, single-phase motors.
2. Three-phase motors with internal thermal protection have thermostats bedded in each phase of the three-phase windings which are connected in series and brought out into the motor conduit box and labeled P1 and P2. The switches are connected into the motor control circuit which will open the magnetic starter contacts when an over temperature condition occurs in the windings.

   Two circuit configurations are available:

   a. One in which the control circuit automatically restarts when the thermal switches and the motor reset, and

   b. A circuit which is locked out and must be manually reset in order to restart.

   Figure 9.11 illustrates a typical control circuit in which normally closed thermostats are connected in series with the motor starter coil in the control circuit. **NOTE:** This is the type of control circuit that will automatically reset when the motor thermostat's switches are reset.

9.343 Increasing Resistance Value

The minimum insulation value in meg ohms is calculated by the following procedures. Divide the rate voltage by 1,000 and add 1 to the result. For example, for a motor operating at 460 volts, the minimum resistance value is 1.46 meg ohms.

$$\frac{460}{1000} + 1 = 1.46$$

Measure the actual insulation resistance using a "megger" and compare the measured "megger" value with the calculated value, then any one of the three following procedures can be used to increase the actual (measured) insulation resistance value. The time required to increase the insulation resistance value depends on the wetness of the insulation and the size of the motor.

1. Remove the motor and bake in an oven at a temperature of not more than 194° F (90° C) until the resistance reaches an acceptable level.

2. Cover motor with a canvas or tarp and insert heating units or lamps. Heat until the resistance reaches an acceptable level. The heating time depends on the number and size of the heating units.
3. Provide a low-voltage current at the motor terminals which will generate heat within the windings. Heat until the resistance reaches an acceptable level.

9.35 Starters

A motor starter is a device or group of devices which are used to connect the electrical power to a motor. These starters can be either manually or automatically controlled.

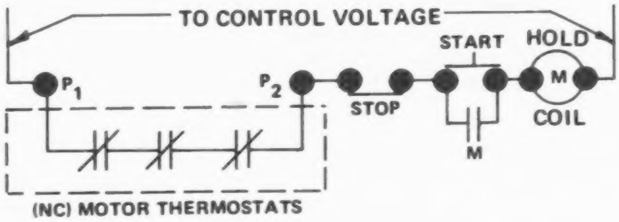


Fig. 9.11 Closed thermostats connected in series with the motor starter coil

Manual and magnetic starters range in complexity from a single "on-off" switch to a sophisticated automatic device using timers and coils. The simplest motor starter is used on single-phase motors where a circuit breaker is turned on and the motor starts. This type of starter also is used on three-phase motors of smaller horsepower as well as on fan motors, machinery motors, and other motors usually where it isn't necessary to have automatic control.

MAGNETIC STARTERS (Figures 9.12 and 9.13) are usually used to start pumps, compressors, blowers, and anything where automatic or remote control is desired. They permit low voltage circuits to energize the starter of equipment at a remote location or to start larger starters (Figure 9.14). A magnetic starter is operated by electromagnetic action. It has contactors and these operate by energizing a coil which closes the contact, thus starting the motor. The circuit that energizes the starter is called the control circuit and it is usually operated on a lower voltage (115 volts) than the motor. Whenever a starter is used as a part of an integrated circuit (such as for flow, pressure or temperature control), a magnetic starter or controller is necessary.

Magnetic starters are sized for their voltage and horsepower ratings. These are divided into classes. The most common starter is Class "A." A Class "A" starter is an "Alternating Current air-break and oil immersed manual, or magnetic controller for service on 600 volts or less. It is capable of interrupting operating overloads up to and including 10 times their normal motor rating, but not short circuits or faults beyond operating overloads."

Additional class information can be found in electrical catalogs, manuals and manufacturers' brochures.

A magnetic starter actually consists of two distinct sections:

1. The contacts which connect and disconnect the power to the motor, and
2. Overload protection.

Figure 9.12 illustrates a three-phase magnetic starter. The replaceable contacts (in the upper portion of the illustration) close when the motor is required to start, thus closing the electrical circuit to the motor. Similarly, when the wet well level gets to a point where the pump is no longer required, a signal is sent to the motor starter and the contacts open, thus breaking the electrical circuit to the motor. Each time this occurs, an arc takes place between the movable contact and the stationary contact and pitting occurs. This is why contacts must be replaced as a regular part of your preventive maintenance program.

The lower portion of Figure 9.12 illustrates the control coil which usually uses a lower voltage than the line voltage to the motors. The magnetic coil is the device that actually causes the contacts to energize and de-energize.

In addition, each phase has an overload protection device that operates as a function of the length of the overload and the amount of the overload. Two types of devices are used, both based on the heating principle:

1. A bimetallic strip which is precisely calibrated to open under higher temperature conditions to de-energize the coil, or
2. A small solder pot within the coil that melts because of the heat and will de-energize the system.

A more common term for the overload protection devices is "heater elements." They are replaceable and can be selected and changed to correspond to the desired trip setting. Typically, the overload heater is selected for a trip setting that will de-energize the contactor when a 10 percent overload occurs.

Figure 9.13 illustrates a wiring diagram of a three-phase magnetic starter and the control coil circuit.

Starters are also available without the overload function. They provide only the motor disconnecting means and are referred to as contactors rather than motor starters. Manual contactors are available as well as magnetic contactors which are capable of automatic control.

Magnetic starter maintenance consists of at least an annual inspection of the equipment, including the following tasks:

1. Inspect line and load conductors for evidence of high temperatures as indicated by bubbling or discoloring of the wire insultation;
2. Tighten all line and load connection terminals, including all low voltage terminals (control, auxiliary switches); and
3. Inspect and replace, if necessary, the stationary and movable contacts. See Figure 9.15 which illustrates the appearance of new contacts, contacts that are used but still suitable for use, and contacts that are used and should be replaced. Troubleshooting charts are given on pages 34 through 38.

CAUTION: No attempt should be made to file down contacts to restore the surface to a new condition, since this will result in an uneven surface and uneven distribution of electrical energy across the face of the contacts.

9.36 Safety

1. The eye bolt used for lifting and moving motors is designed for the weight of the motor alone without other equipment attached.
2. Whenever physically working on rotating equipment, including the pump and the motor, open and lock out the electrical disconnect switch. This will prevent accidental energization of the motor, either by a careless operator or as a result of motor thermal switches automatically resetting and restarting the motor.
3. Ground all motors in accordance with requirements of National Electrical Code, Article 340.
4. Always keep hands and clothing away from moving parts.
5. Discharge all capacitors including power factor direction capacitors before servicing motor or motor controller.
6. Be sure that required safety guards are always in place.

9.37 Other Motor Considerations

9.371 Alignment

Horizontal motors should be mounted so that all four mounting feet are aligned to within 0.010 inches of each other for NEMA Frame 56 to NEMA Frame 210 and within 0.015 inches for NEMA Frame 250 through NEMA Frame 680. This alignment ensures a good, rigid foundation and also will make alignment of the motor and pump easier.

The purpose of the coupling is to transmit power and, unless the coupling is of special design, it is not to be used to compensate for angular or parallel misalignment between

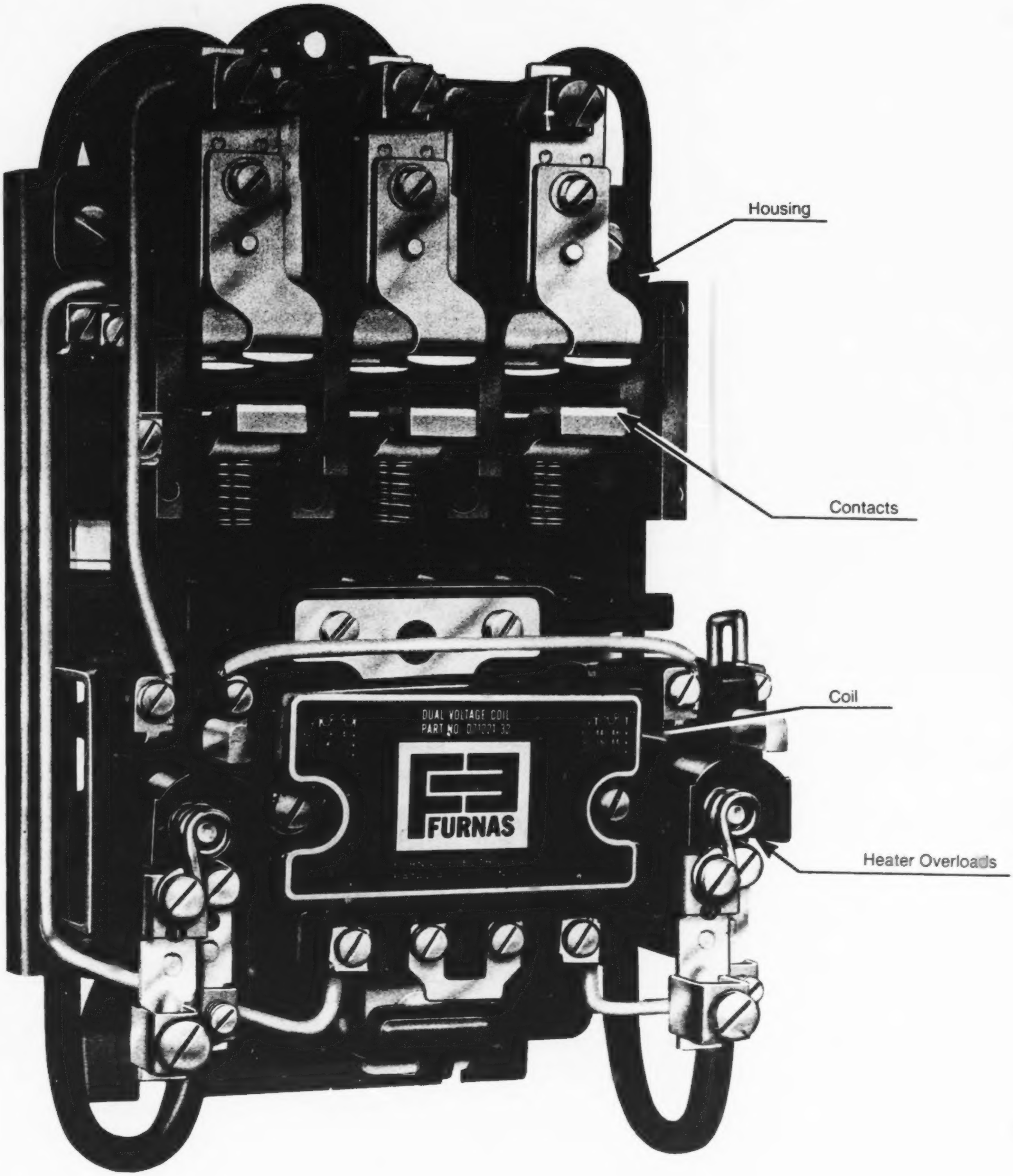

Housing
Contacts
DUAL VOLTAGE COIL
Coil
FURNAS
Heater Overloads

Fig. 9.12 Three-phase magnetic starter
(Courtesy of Furnas Electric Company)

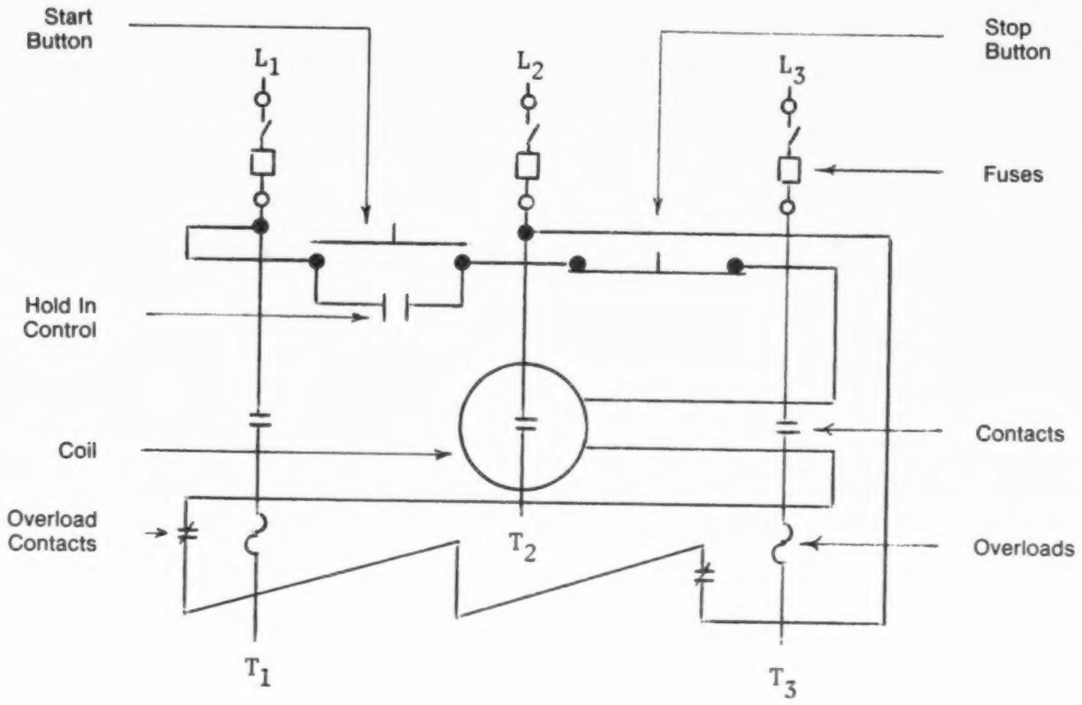

Start Button
Stop Button
L_1
L_2
L_3
Fuses
Hold In Control
Contacts
Coil
Overload Contacts
Overloads
T_1
T_2
T_3

Fig. 9.13 Wiring diagram of three-phase magnetic starter

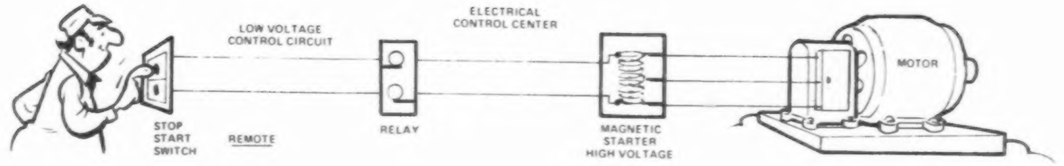
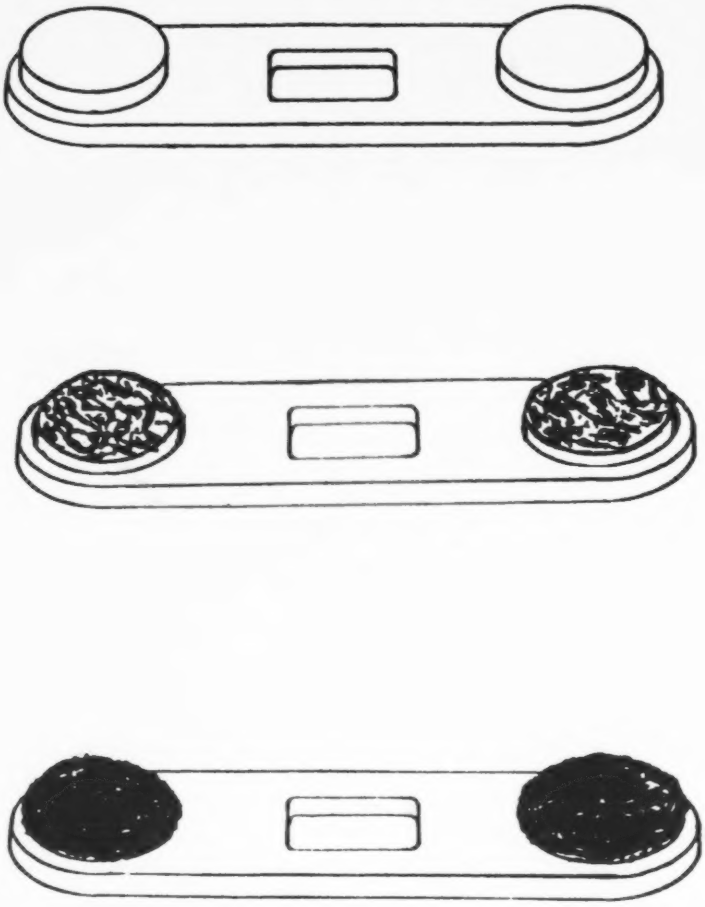

LOW VOLTAGE CONTROL CIRCUIT
ELECTRICAL CONTROL CENTER
STOP START SWITCH
REMOTE
RELAY
MAGNETIC STARTER HIGH VOLTAGE
MOTOR

Fig. 9.14 Application of magnetic starter



NEW

Smooth surface. May be bright or dull and somewhat discolored due oxidation or tarnishing.

USED

Surface may be pitted and have discolored areas of black, brown or may have blue (heat) tint. If half of the thickness (mass) of the silver points is still intact they are usable. This is the time to order a back-up set.

SEVERE OR LONG-TIME USE

Surface badly pitted and eroded with badly feathered and lifting edges. Replace entire contact sets.

Fig. 9.15 Visual inspection of contact points

the motor and the pump. Misalignment can cause excessive bearing loading as well as shaft bending causing premature bearing failure, excessive vibration or permanent damage to the shaft.

A general rule of thumb is that angular misalignment of the shafts must not exceed a total indicator reading of 0.002 inches for each inch of diameter of the coupling hub. To check for angular misalingment, mount a dial indicator on one coupling hub as shown in Diagram 1, Figure 9.16, with the finger or the button of the indicator against the finished face of the other hub and the dial set at zero. While rotating the shaft, note the reading on the indicator dial at each revolution.

Runout should also be checked. This checks the trueness or straightness of the shaft. Diagram 2, Figure 9.16, illustrates how the trueness is checked with the dial indicator mounted, again, on one coupling hub and the finger or button mounted on the outside surface of the second hub. As the shaft is rotated, note the indicator reading. The reading should not exceed 0.002 inches. A reading in excess of 0.002 inches indicates a bent shaft or a shaft that is eccentrically machined.

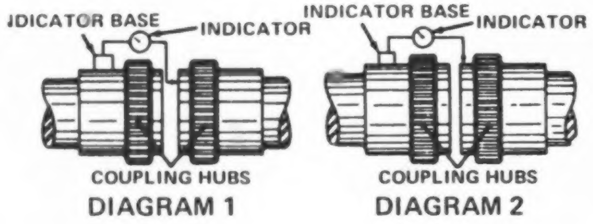


Fig. 9.16 Use of dial indicator to check for shaft angular alignment and trueness

9.372 Changing Rotation Direction

Changing the rotation direction of a three-phase motor is accomplished by simply changing any two of the power leads. Generally, this is done on the load side of a magnetic starter. The direction of motor rotation must be changed if a pump is rotating in the wrong direction.

TABLE 9.4 TYPICAL MOTOR PERFORMANCE VARIATIONS DUE TO POWER SUPPLY VARIATIONS

POLYPHASE - INTEGRAL HORSEPOWER

				TORQUE				Speed Full-Load	Power Factor Full-Load
				Starting (Locked Rotor)	DIP	Break-Down	Full-Load		
		1% Unbalance		Slight –	Slight –	Slight –	Slight +	Slight –	–5.5%
		2% Unbalance		Slight –	Slight –	Slight –	Slight +	Slight –	–7.1%
VOLTAGE	DP	110% of Rated Volt.	1-10 HP	+21 to 23%	+21 to 23%	+21 to 23%	–1.0%	+1.0%	–13 to 10%
			15-30 HP				–0.6%	+0.6%	–9 to 8%
			40-75 HP				–0.5%	+0.5%	–8 to 6%
			100-200 HP				–0.3%	+0.3%	–6 to 4%
		90% of Rated Volt.	1-10 HP	–17 to 19%	–17 to 19%	–17 to 19%	+1.5%	–1.5%	+11 to 7%
			15-30 HP				+1.0%	–1.0%	+6 to 3%
			40-75 HP				+0.6%	–0.6%	+3 to 2%
			100-200 HP				+0.3%	–0.3%	+2 to 3%
	TEFC	110% of Rated Volt.	1-10 HP	+21 to 23%	+21 to 23%	+21 to 23%	–1.0%	+1.0%	–13 to 6%
			15-30 HP				–0.6%	+0.6%	–5 to 3%
			40-75 HP				–0.5%	+0.5%	–3 to 2%
			100-200 HP				–0.3%	+0.3%	+2 to 0%
		90% of Rated Volt.	1-10 HP	–17 to 19%	–17 to 19%	–17 to 19%	+1.5%	–1.5%	+11 to 4%
			15-30 HP				+1.0%	–1.0%	+2 to 0%
			40-75 HP				+0.6%	–0.6%	+1 to 0%
			100-200 HP				+0.3%	–0.3%	+1 to 0%
FREQ	DP & TEFC	105% of Rated Freq.	1 to 200 HP	–10%	–10%	–10%	–5%	+5%	Slight +
		95% of Rated Freq.	1 to 200 HP	+11%	+11%	+11%	+5%	–5%	Slight –

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TABLE 9.5 TYPICAL MOTOR PERFORMANCE VARIATIONS DUE TO POWER SUPPLY VARIATIONS

				AMPS			Effic. Full-Load	Temp. Rise Full-Load
				Starting (Locked Rotor)	Full-Load	No-Load		
		1% Unbalance		+1.5%	+8%	+13%	−2%	+2%
		2% Unbalance		+3%	+17%	+27%	−8%	+8%
VOLTAGE	DP	110% of Rated Volt.	1-10 HP	+10 to 12%	+8 to 4%	+25 to 37%	−6 to 1%	+17 to 9%
			15-30 HP		+4 to 1%	+32 to 37%	−1 to 0%	+7 to 3%
			40-75 HP		−0 to 2%	+37%	No Change	+2 to 0%
			100-200 HP		−3 to 5%	+36 to 30%	+0 to 0.3%	−0 to 4%
		90% of Rated Volt.	1-10 HP	−10 to 12%	−3 to +5%	−20 to 19%	+1 to 0%	−6 to +12%
			15-30 HP		+6 to 9%	−19 to 18%	−0 to 0.4%	+15 to 19%
			40-75 HP		+9 to 10%	−18 to 17%	−0.4 to 0.1%	+19 to 20%
			100-200 HP		+9 to 10%	−17 to 16%	−0.1%	+19 to 20%
	TEFC	110% of Rated Volt.	1-10 HP	+10 to 12%	+8 to −4%	+37 to 27%	−6 to 1%	+17 to −5%
			15-30 HP		−5 to 6%	+26 to 25%	−1 to 0%	−7 to 9%
			40-75 HP		−6 to 7%	+24 to 21%	No Change	−9 to 10%
			100-200 HP		−7 to 9%	+20 to 13%	+0 to 0.3%	−10 to 11%
		90% of Rated Volt.	1-10 HP	−10 to 12%	−3 to +5%	−20 to 16%	+1 to 0%	−6 to +15%
			15-30 HP		+6 to 11%	−14 to 12%	−0 to 0.4%	+19 to 23%
			40-75 HP		+12%	−12 to 10%	−0.4 to 0.1%	+24 to 23%
			100-200 HP		+11 to 9%	−10%	−0.1%	+24 to 23%
FREQ	DP & TEFC	105% of Rated Freq.	1 to 200 HP	−5 to 6%	Slight −	−5 to 6%	Slight +	Slight −
		95% of Rated Freq.	1 to 200 HP	+5 to 6%	Slight +	+5 to 6%	Slight −	Slight +

+ Increase
− Decrease

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9.373 Allowable Voltage and Frequency Deviations

1. Voltage 10 percent above or below the value stamped in the nameplate.
2. Frequency 5 percent above or below the value stamped in the nameplate.
3. Voltage and frequency together within 10 percent providing frequency is less than 5 percent above or below the value stamped in the nameplate.

As mentioned previously, both voltage and frequency have a direct effect on the performance and life of the motor as illustrated in Tables 9.4 and 9.5. A 10 percent increase in the rated voltage, for example, results in a 0 to 17 percent increase in temperature, which will have a significant effect on the insulation life of the motor (see Table 9.5, Voltage DP, 110% of Rated Voltage, 1-200 HP, Temperature Rise, Full-Load, 0 to 17%).

9.374 Maximum Vibration Levels Allowed by NEMA

SPEED, RPM	MAXIMUM VIBRATION AMPLITUDE, INCHES
1. 3,000 - 4,000	0.001
2. 1,500 - 2,999	0.002
3. 1,000 - 1,499	0.0025
4. 999 or less	0.003

9.735 Lubrication

The correct procedure for lubricating motors is as follows:

1. Stop motor and lock out;
2. Wipe all grease fittings;
3. Remove filler and drain plugs (CAUTION, Zerk fittings should NOT be installed in both the filler and the drain holes);
4. Free drain hole of any hard grease using a piece of wire, if necessary;

5. Add appropriate amount of grease using low-pressure grease gun;
6. Start motor and let run for approximately 30 minutes. (This allows excess grease to drain out. If this is not done, pressure buildup in the bearing can blow out the bottom seal, allowing grease to run down the shaft on to the top of the motor windings.); and
7. Stop motor, wipe off any drained grease, replace filter and drain plugs.

Figure 9.17 shows a cross-section of the bearing cap and filler/drain plugs.

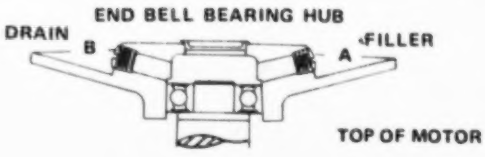


Fig. 9.17 Cross-section of bearing cap and filler/drain plugs

Excessive greasing can cause as much damage to motor bearings as under-greasing. Therefore, manufacturer's recommendations should be followed without exception. The amount and frequency of greasing depends on a number of factors including RPM, operating temperature, duty cycle, and environmental conditions.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 229.

9.3A What are the two types of induction motor construction typically encountered when dealing with AC induction motors?

9.3B List the five most common causes of electric motor failure.

9.3C List the three components of an insulation temperature rating.

9.3D How can the direction of rotation of a three-phase motor be changed?

9.3E How are motor starters controlled?

9.3F When are magnetic starters used?

9.3G What two types of overload protection devices are used on magnetic starters?

9.38 Troubleshooting

9.381 Step-by-Step Procedures

Practical step-by-step procedures combined with a common sense approach is the key to effective troubleshooting.

"NEVER TAKE ANYTHING FOR GRANTED"

A. Gather preliminary information. The first step in troubleshooting any motor control which has developed trouble, is to understand the circuit operation and other related functions. In other words, what is supposed to happen, operate, and so forth when it's working right? Also what is it doing now? The qualified maintenance operator should be able to do the following:

   1. *KNOW WHAT SHOULD HAPPEN WHEN A SWITCH IS PUSHED:* When switches are pushed or tripped, what coils go in, contacts close, relays operate, and motors run.
   2. *EXAMINE ALL OTHER FACTORS:* What other unusual things are happening in the lift station (facility) now that this circuit doesn't work properly? Lights dimmed, other pumps ran faster, lights went out when it broke, everything was flooded, operators were hosing down area, and many other possible factors.

3. *ANALYZE WHAT YOU KNOW:* What part of it is working correctly? Is switch arm tripped? Everything but this is all right, except pump gets plugged with rags frequently. Is it a mechanical failure or an electrical problem caused by a mechanical failure?

4. *SELECT SIMPLE PROCEDURES:* To localize the problem, select logical ways that can be simply and quickly accomplished.

5. *MAKE A VISUAL INSPECTION:* Look for burned wires, loose wires, area full of water, coil burned, contacts loose, or strange smells.

6. *CONVERGE ON SOURCE OF TROUBLE:* Mechanical or electrical. Motor or control, whatever it might be. Electrical problems result from some type of mechanical failure.

7. *PINPOINT THE PROBLEM:* Exactly where is the problem and what do you need for repair?

8. *FIND THE CAUSE:* What caused the problem? Moisture, wear, poor design, voltage, or overloading.

9. *REPAIR THE PROBLEM AND ELIMINATE THE CAUSE IF POSSIBLE:* If the problem is inside switch gear or motors, call an electrician. Give the electrician the information you have regarding the equipment. Do not attempt electrical repairs unless qualified and authorized, otherwise you could cause excessive damage to yourself and to the equipment.

B. Some of the things to look for when troubleshooting are given in the remainder of this section.

1. Contacts

Trouble	**Possible Cause**	**Remedy**
Contact chatter	1. Broken *POLE SHADER*[4].	1. Replace.
	2. Poor contact in control circuit.	2. Improve contact or use holding circuit interlock.
	3. Low voltage.	3. Correct voltage condition. Check momentary voltage dip.
Welding or freezing	1. Abnormal surge of current.	1. Use larger contactor and check for grounds, shorts, or excessive motor load current.
	2. Frequent *JOGGING*[5].	2. Install larger device rated for jogging service or caution operator.
	3. Insufficient contact pressure.	3. Replace contact spring; check contact carrier for damage.
	4. Contacts not positioning properly.	4. Check for voltage dip during startup.
	5. Foreign matter preventing magnet from seating.	5. Clean contacts.
	6. Short circuit.	6. Remove short fault and check that fuse or breaker are right.
Short contact life or over-heating of tips	1. Contacts poorly aligned, spaced or damaged.	1. Do not file silver-faced contacts. Rough spots or discoloration will not harm contacts.
	2. Excessively high currents.	2. Install larger device. Check for grounds, shorts, or excessive motor currents.
	3. Excessive starting and stopping of motor.	3. Caution operators. Check operating controls.
	4. Weak contact pressure.	4. Adjust or replace contact springs.
	5. Dirty contacts.	5. Clean with approved solvent.
	6. Loose connections.	6. Check terminals and tighten.

---

[4] *Pole shader. Separations on the iron core inside the coil of a magnetic starter.*

[5] *Jogging. Starting and stopping.*

Trouble	Possible Cause	Remedy
Coil, overheated	1. Starting coil may not kick out.	1. Repair coil.
	2. Overload won't let motor reach minimum speed.	2. Remove overload.
	3. Over-voltage or high ambient temperature.	3. Check application and circuit.
	4. Incorrect coil.	4. Check rating and if incorrect, replace with proper coil.
	5. Shorted turns caused by mechanical damage or corrosion.	5. Replace coil.
	6. Undervoltage, failure of magnet to seal it.	6. Correct system voltage.
	7. Dirt or rust on pole faces increasing air gap.	7. Clean pole faces.
Overload relays tripping	1. Sustained overload.	1. Check for grounds, shorts or excessive motor currents. Mechanical overload.
	2. Loose connection on all or any load wires.	2. Check, clean, and tighten.
	3. Incorrect heater.	3. Replace with correct size heater unit.
	4. Fatigued heater blocks.	4. Inspect and replace.
Failure to trip	1. Mechanical binding, dirt, or corrosion.	1. Clean or replace.
	2. Wrong heater, or heaters omitted and jumper wires used.	2. Check ratings. Apply heaters of proper rating.
	3. Motor and relay in different temperatures.	3. Adjust relay rating accordingly, or install temperature compensating relays.

2. Magnetic and Mechanical Parts

Trouble	Possible Cause	Remedy
Noisy magnet (humming)	1. Broken shading coil.	1. Replace shading coil.
	2. Magnet faces not mating.	2. Replace magnet assembly or realign.
	3. Dirt or rust on magnet faces.	3. Clean and realign.
	4. Low voltage	4. Inspect system voltage and voltage dips during starting.
Failure to pick up and seal	1. Low voltage.	1. Inspect system voltage and correct.
	2. Coil open or shorted.	2. Replace.
	3. Wrong coil.	3. Check coil number and voltage rating.
	4. Mechanical obstruction.	4. With power off, check for free movement of contact and armature assembly. Repair.
Failure to drop out	1. Gummy substance on pole.	1. Clean with solvent.
	2. Voltage not removed from coil.	2. Check coil circuit.
	3. Worn or rusted parts causing binding.	3. Replace or clean parts as necessary.
	4. Residual magnetism due to lack of air gap in magnet path.	4. Replace worn magnet parts or align if possible.
	5. Welded contacts.	5. Shorted circuit, grounded, overload.

9.382. Troubleshooting Guide For Electric Motors

SYMPTOMS	CAUSE	RESULT*	REMEDY
1. Motor does not start. (Switch is on and not defective.)	a. Incorrectly connected.	a. Burnout	a. Connect correctly per diagram on motor.
	b. Incorrect power supply.	b. Burnout	b. Use only with correct rated power supply.
	c. Fuse out, loose or open connection.	c. Burnout	c. Correct open circuit condition.
	d. Rotating parts of motor may be jammed mechanically.	d. Burnout	d. Check and correct: 1. Bent shaft 2. Broken housing 3. Damaged bearing 4. Foreign material in motor.
	e. Driven machine may be jammed.	e. Burnout	e. Correct jammed condition.
	f. No power supply.	f. None	f. Check for voltage at motor and work back to power supply.
	g. Internal circuitry open.	g. Burnout	g. Correct open circuit condition.
2. Motor starts but does not come up to speed.	a. Same as 1-a, b, c above.	a. Burnout	a. Same as 1-a, b, c above.
	b. Overload.	b. Burnout	b. Reduce load to bring current to rated limit. Use proper fuses and overload protection.
	c. One or more phases out on a 3 phase motor.	c. Burnout	c Look for open circuits.
3. Motor noisy electrically.	a. Same as 1-a, b, c above.	a. Burnout	a. Same as 1-a, b, c above.
4. Motor runs hot (exceeds rating).	a. Same as 1-a, b, c above.	a. Burnout	a. Same as 1-a, b, c above.
	b. Overload	b. Burnout	b. Reduce load.
	c. Impaired ventilation.	c. Burnout	c. Remove obstruction.
	d. Frequent start or stop.	d. Burnout	d. 1. Reduce number of starts or reversals. 2. Secure proper motor for this duty.
	e. Misalignment between rotor and stator laminations.	e. Burnout	e. Realign.

*Many of these conditions should trip protective devices rather than burn out motors.

SYMPTOMS	CAUSE	RESULT	REMEDY
5. Noisy (mechanically)	a. Misalignment of coupling or sprocket.	a. Bearing failure, broken shaft, stator burnout due to motor drag.	a. Correct misalignment.
	b. Mechanical unbalance of rotating parts.	b. Same as 5-a.	b. Find unbalanced part, then balance.
	c. Lack of or improper lubricant.	c. Bearing failure.	c. Use correct lubricant, replace parts as necessary.
	d. Foreign material in lubricant.	d. Same as 5-c.	d. Clean out and replace bearings.
	e. Overload.	e. Same as 5-c.	e. Remove overload condition. Replace damaged parts.
	f. Shock loading.	f. Same as 5-c.	f. Correct causes and replace damaged parts.
	g. Mounting acts as amplifier of normal noise.	g. Annoying.	g. Isolate motor from base.
	h. Rotor dragging due to worn bearings, shaft or bracket.	h. Burnout	h. Replace bearings, shaft or bracket as needed.
6. Bearing failure	a. Same as 5-a, b, c, d, e	a. Burnout, damaged shaft, damaged housing.	a. Replace bearings and follow 5-a,b,c,d,e.
	b. Entry of water or foreign material into bearing housing.	b. Same as 6-a.	b. Replace bearings and seals and shield against entry of foreign material (water, dust, etc.). Use proper motor.

SYMPTOM	CAUSED BY	APPEARANCE
1. Shorted motor winding	a. Moisture, chemicals, foreign material in motor, damaged winding.	a. Black or burned coil with remainder of winding good.
2. All windings completely burned	a. Overload.	a. Burned equally all around winding
	b. Stalled.	b. Burned equally all around winding
	c. Impaired ventilation.	c. Burned equally all around winding
	d. Frequent reversal or starting.	d. Burned equally all around winding
	e. Incorrect power.	e. Burned equally all around winding
3. Single-phase condition	a. Open circuit in one line. The most common causes are loose connection, one fuse out, loose contact in switch.	a. If 1800 RPM motor - four equally burned groups at 90° intervals. b. If 1200 RPM motor - six equally burned groups at 60° intervals. c. If 3600 RPM motor - two equally burned groups at 180°. NOTE: If Y connected, each burned group will consist of two adjacent phase groups. If delta connected, each burned group will consist of one-phase group.
4. Other	a. Improper connection.	a. Irregularly burned groups or spot burns.
	b. Ground.	

Many burnouts occur within a short period of time after motor is started up. This does not necessarily indicate that the motor was defective, but usually is due to one or more of the above-mentioned causes. The most common of these are improper connections, open circuits in one line, incorrect power supply or overload.

9.383 Trouble-Remedy Chart for Induction Motors

A. Motor will not start.
Overload control tripped. Wait for overload to cool, then try to start again. If motor still does not start, check for the causes outlined below.

1. Open fuses: test fuses.
2. Low voltage: check nameplate values against power supply characteristics. Also check voltage at motor terminals when starting motor under load to check for allowable voltage drop.
3. Wrong control connections: check connections with control wiring diagram.
4. Loose terminal-lead connection: turn power off and tighten connections.
5. Drive machine locked: disconnect motor from load. If motor starts satisfactorily, check driven machine.
6. Open circuit in stator or rotor winding: check for open circuits.
7. Short circuit in stator winding: check for short.
8. Winding grounded: test for grounded wiring.
9. Bearing stiff: free bearing or replace.
10. Overload: reduce load.

B. Motor noisy.

1. Three-phase motor running on single phase: stop motor, then try to start. It will not start on single phase. Check for open circuit in one of the lines.
2. Electrical load unbalanced: check current balance.
3. Shaft bumping (sleeve-bearing motor): check alignment and conditions of belt. On pedestal-mounted bearing check cord play and axial centering of rotor.
4. Vibration: driven machine may be unbalanced. Remove motor from load. If motor is still noisy, rebalance.
5. Air gap not uniform: center the rotor and if necessary replace bearings.
6. Nosiy ball bearing: check lubrication. Replace bearings if noise is excessive and persistent.
7. Rotor rubbing on stator: center the rotor and replace bearings if necessary.
8. Motor loose on foundation: tighten hold-down bolts. Motor may possibly have to be realigned.
9. Coupling loose: insert feelers at four places in coupling joint before pulling up bolts to check alignment. Tighten coupling bolts securely.

C. Motor at higher than normal temperature or smoking. (Measure temperature with thermometer or thermister and compare with nameplate value.)

1. Overload: measure motor loading with ammeter. Reduce load.
2. Electrical load imbalance: check for voltage imbalance or single-phasing.
3. Restricted ventilation: clean air passage and windings.
4. Incorrect voltage and frequency: check nameplate values with power supply. Also check voltage at motor terminals with motor under full load.
5. Motor stalled by driven tight bearings: remove power from motor. Check machine for cause of stalling.
6. Stator winding shorted or grounded: test windings by standard method.
7. Rotor winding with loose connection: tighten, if possible, or replace with another rotor.
8. Belt too tight: remove excessive pressure on bearings.
9. Motor used for rapid reversing service: replace with motor designed for this service.

D. Bearings hot.

1. End shields loose or not replaced properly: make sure end shields fit squarely and are properly tightened.
2. Excessive belt tension or excessive gear side thrust: reduce belt tension or gear pressure and realign shafts. See that thrust is not being transferred to motor bearing.
3. Bent shaft: straighten shaft or send to motor repair shop.

E. Sleeve bearings.

1. Insufficient oil: add oil — if supply is very low, drain, flush, and refill.
2. Foreign material in oil or poor grade of oil: drain oil, flush, and relubricate using industrial lubricant recommended by a reliable oil manufacturer.
3. Oil rings rotating slowly or not rotating at all: oil too heavy; drain and replace. If oil ring has worn spot, replace with new ring.
4. Motor tilted too far: level motor or reduce tilt and realign if necessary.
5. Rings bent or otherwise damaged in reassembling: replace rings.
6. Rings out of slot (oil-ring retaining clip out of place): adjust or replace retaining clip.
7. Defective bearings or rough shaft: replace bearings. Resurface shaft.

F. Ball bearings.

1. Too much grease: remove relief plug and let motor run. If excess grease does not come out, flush and relubricate.
2. Wrong grade of grease: flush bearing and relubricate with correct amount of proper grease.
3. Insufficient grease: remove relief plug and grease bearing.
4. Foreign material in grease: flush bearing, relubricate; make sure grease supply is clean (keep can covered when not in use).

9.39 RECORDS

Records are a very important part of electrical maintenance. They must be accurate and complete. Pages 160 and 161 are examples of typical record sheets. Most of the information you will need to complete these forms can be found on the manufacturer's data sheet or in the instruction manual.

Whenever a piece of equipment is changed, repaired, or tested, it should be recorded on a material history card of some type. Complete, up-to-date equipment records will enable you to evaluate the reliability of your equipment and will provide the basis for a realistic preventive maintenance program.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 229.

9.3H What is the key to effective troubleshooting?

9.3I What are some of the steps that should be taken when troubleshooting electrical equipment?

9.3J What kind of information should be recorded regarding electrical equipment?

Additional Reading

1. BASIC ELECTRICITY by Van Valkenburgh, Nooger & Neville, Inc. Obtain from the Brolet Press, 3 Gold Street, New York, NY 10038. Price $39.95 for combined edition; $52.50 for set of five individual volumes.
    a. Volume 1.
    Where Electricity Comes From
    Electricity in Action
    Current Flow, Voltage, Resistance
    Magnetism, DC Meters

    b. Volume 2.
    Direct Current
    Ohm's and Kirchoff's Laws
    Electric Power

    c. Volume 3.
    Alternating Current
    Resistance, Inductance, Capacitance in AC
    Reactance
    AC Meters

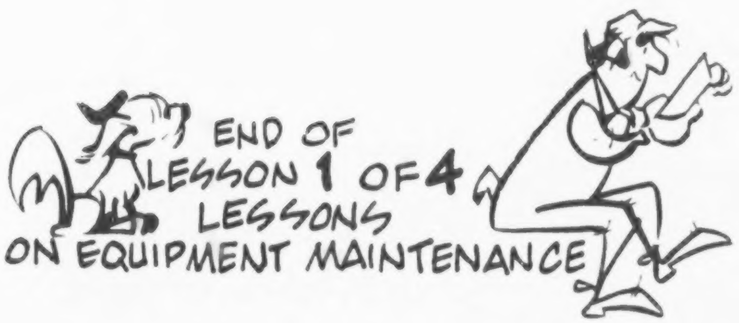
    d. Volume 4.
    Impedance
    Alternating Current Circuits
    Series and Parallel Resonance
    Transformers

    e. Volume 5.
    DC Generators and Motors
    Alternators and AC Motors
    Power Control Devices

    f. Other Training Programs
    Basic Electronics, 6 Volumes
    Basic Industrial Electricity, 2 Volumes

    NOTE: For an additional $2.00 per volume, you can obtain an "Interactive Self-Learning Package."

2. "Maintenance" by Stan Walton, Volume II, Chapter 15, in *OPERATION OF WASTEWATER TREATMENT PLANTS,* Kenneth D. Kerri, California State University, Sacramento, 6000 J Street, Sacramento, CA 95819. Price for Volume II, $25.00.
3. "Instrumentation" by George Ohara, Chapter 8 in *ADVANCED WASTE TREATMENT,* Kenneth D. Kerri, California State University, Sacramento, 6000 J Street, Sacramento, CA 95819. Price $20.00.
4. "Maintenance" by Parker Robinson, *WATER TREATMENT PLANT OPERATION,* Volume II, Kenneth D. Kerri, California State University, Sacramento, 6000 J Street, Sacramento, CA 95819. Price $30.00.
5. *ELECTRICITY PRINCIPLES AND PRACTICES* by Adams, McGraw-Hill Book Company, 8171 Redwood Highway, Novato, CA 94547. Price $27.00.
6. *MAINTENANCE ENGINEERING HANDBOOK* by Higgins, McGraw-Hill Book Company, P.O. Box 402, Hightstown, NJ 08520. Price $82.50.



PUMP RECORD CARD

NAME ________ MAKE ________ MODEL ________

TYPE ________ SIZE ________ SERIAL # ________

ORDER NUMBER ________ SUPPLIER ________ DATE PURCHASED ________

DATE INSTALLED ________ APPLICATION ________ PLANT # ________

Nameplate Data and Pump Info	Stuffing Box Data	Motor Data
GPM ________	Diameter ____ Depth ____	Name ________ Serial # ________
TDH ________	Pack. Size ____ Type ____	H.P. ________ Speed ________
RPM ________	Length ____ No. Rings ____	Ambient° ________
Gage Press Disc ____ ________	Lantern Ring ____ Flushed ____	RPM ____ Frame ________
Gage Press Suc ____ ________	Mech. Seal Name ____ Size ____	Volts ____ Amps ________
Shut off Press ____ ________	Type ________	Phase ____ Cycle ________
Suction Head ____ ________	Pump Materials	Shaft Size ____ Key ____
Rotation ____ ________	Casing ________	Bearing Front ________
Impeller Type ________	Shaft ________	Rear ________
Impeller Dia. ________	Wearing Rings Casing ________	Code ____ Type ________
Impeller Clear ________	Wearing Rings Impeller ________	Amps @ Max Speed ________
Coupl Type & Size ________	Shaft Sleeve ________	Amps @ Shut Off ________
Front Brg # ________	Slinger ________	Control Data Info
Rear Brg # ________	Shims ________	Starter ________
Lub Interval ________	Gaskets ________	MENA Size ________
Lubricant ________	"O" Rings ________	Cat. # ________
Wearing Rings ________	Brg. Seals Front ________	Heater Size ________
Shaft Sleeve Size ________	Rear ________	Rated @ ________
Pump Shaft Size ________	Casing Wear Ring Size ID ________	Control Voltage ________
Pump Keyway ________	OD ________	Variable Speed Type ________
________	Width ________	Speed Max ________
Other Related Information:	Impeller Wear Ring ID ________	Speed Min ________
	OD ________	
	Width ________	

MOTOR STARTERS

Number ____________

Title: ____________

Mfg.: ____________ Address ____________

Style: ____________ Class ____________ Size ____________

Type: ____________ ____________ ____________

O.L. HEATERS

Style ____________ Code ____________

Amps ____________ ____________

____________ ____________

O.L. TRIP UNITS

Mfg: ____________ Style: ____________

Type: ____________ ____________

Amps Range: ____________ ____________

CIRCUIT BREAKER

Mfg: ____________ Address ____________

Style: ____________ Frame: ____________ Volts ____________ Amps Setting ____________

Cat. No. ____________ ____________ ____________ ____________

MOTOR

Number ____________

TITLE ____________

Mfg: ____________ Address ____________

HP: ____________ Volts: ____________ Ser. No. ____________ Duty: ____________

Phase: ____________ Amps: ____________ Frame: ____________ Temp: ____________

Cycles: ____________ RPM: ____________ Type ____________ Class: ____________

Code: ____________ S.F.: ____________ Model ____________ Spec.: ____________

SO# ____________ S# ____________ Style: ____________ CSA App: ____________

Form ____________ Spec. ____________ Shft. Brg. ____________ Rear Brg. ____________

50 Cycle Data ____________

Suitable for 208V Network: ____________

Additional data ____________

____

____

____

Connection Diagram

(6) (5) (4)
(7) (8) (9)
(1) (2) (3)

(6) (5) (4)
(7) (8) (9)
(1) (2) (3)

DISCUSSION AND REVIEW QUESTIONS

Chapter 9. EQUIPMENT MAINTENANCE

(Lesson 1 of 4 Lessons)

At the end of each lesson in this chapter you will find some discussion and review questions that you should answer before continuing. The purpose of these questions is to indicate to you how well you understand the material in the lesson. Write the answers to these questions in your notebook before continuing.

1. Why should inexperienced, unqualified or unauthorized persons and even qualified and authorized persons be extremely careful around electrical panels, circuits, wiring and equipment?
2. What is the difference between direct current (D.C.) and alternating current (A.C.)?
3. What meters and testers are used to maintain, repair and troubleshoot electrical circuits and equipment? Discuss the use of each meter and tester.
4. What protective or safety devices are used to protect operators and equipment from being harmed by electricity?
5. Why must motor name plate data be recorded and filed?
6. How would you attempt to find the cause of a pump motor that won't start?

CHAPTER 9. EQUIPMENT MAINTENANCE

(Lesson 2 of 4 Lessons)

9.4 PUMPS

Pumps are used to move wastewater in collection systems when a gravity system is not feasible or too costly. In the collection system they are used in lift stations where it is necessary to lift the water from a low elevation to a higher elevation. Pumps also are used in high velocity cleaners for cleaning collection systems. They are used to dewater trenches or excavations while installing pipe lines or repairing them. Automobiles have oil pumps and water pumps, while backhoes have hydraulic pumps.

These pumps vary in type, construction, and use. There are centrifugal pumps, reciprocating pumps, turbine pumps, diaphragm pumps, gear pumps, screw pumps, and many others. Each type of pump is designed for a particular job or application.

Pump selection is based on several factors. Important considerations should include the three factors listed below.

1. Type of material to be pumped:
   A. Wastewater,
   B. Storm water,
   C. Sludge, grit,
   D. Mud, rocks, sand,
   E. Oil, and
   F. Clear water.
2. Type of service required:
   A. High pressure — low volume,
   B. High pressure — high volume,
   C. Low pressure — low volume, and
   D. Low pressure — high volume.

3. Other factors should include:
   A. Reliability,
   B. Required maintenance,
   C. Parts availability,
   D. Efficiencies, and
   E. Operating conditions.

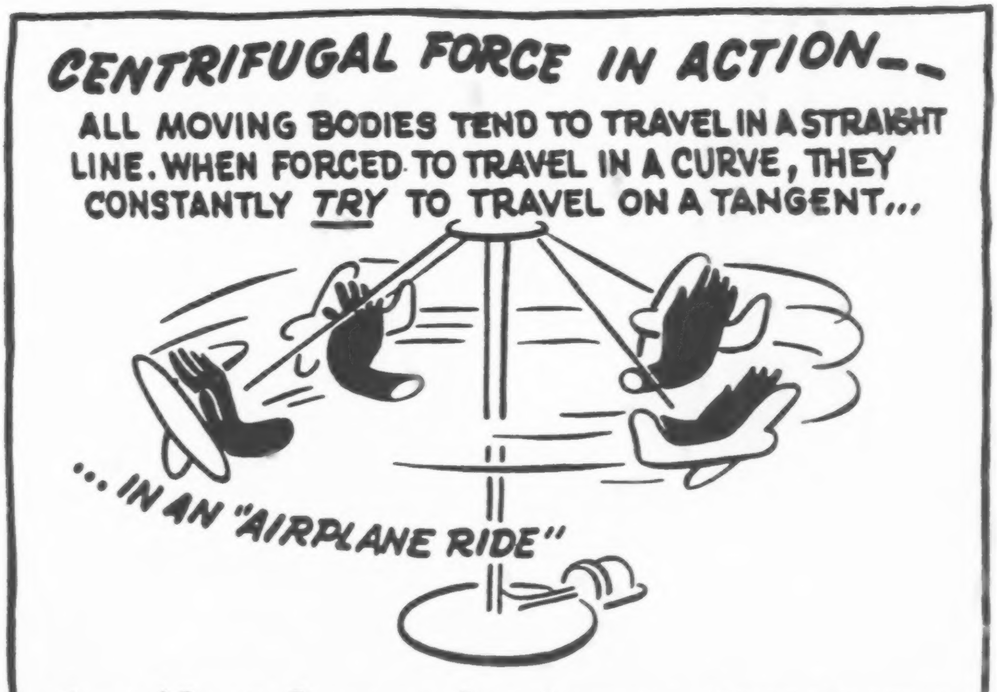
Generally, centrifugal pumps are used for pumping wastewater; piston or diaphragm pumps for heavy solids; gear pumps and piston pumps for high pressures; and turbine or propeller pumps for mixing air or chemicals.

Pumps are so varied in their construction, operation, and maintenance that it is necessary to consult each manufacturer's instruction book for information regarding your particular pump. Each and every type and manufacturer of pumps cannot be discussed in this section, but several of the common types used in wastewater collection will be studied.

To better understand pumps and parts, the following section "Let's Build a Centrifugal Pump" is presented. The pump described is a clearwater pump, not a wastewater pump, but there are many similarities. The major difference is that wastewater pumps have open impellers (big openings) instead of closed impellers (small openings).

9.41 Let's Build a Pump

This section is reproduced with the permission of Allis-Chalmers Corporation, Milwaukee, Wisconsin, Industrial Pump Division, Norwood, Ohio. Originally, the material was printed in Allis-Chalmers bulletin No. OBX62568.


CENTRIFUGAL FORCE IN ACTION--
ALL MOVING BODIES TEND TO TRAVEL IN A STRAIGHT LINE. WHEN FORCED TO TRAVEL IN A CURVE, THEY CONSTANTLY TRY TO TRAVEL ON A TANGENT,..
...IN AN "AIRPLANE RIDE"
Centrifugal force pushes dummy planes swung in a circle away from center of rotation.
...IN A WHIRLPOOL
Centrifugal force tends to push swirling water outward... forming vortex in center.

Let's Build a Pump!

A student of medicine spends long years learning exactly how the human body is built before attempting to prescribe for its care. Knowledge of *PUMP* anatomy is equally basic in caring for centrifugal pumps!

But whereas the medical student must take a body apart to learn its secrets, it will be far more instructive to us if we put a pump *TOGETHER* (on paper, of course). Then we can start at the beginning — adding each new part as we need it in logical sequence.

As we see *WHAT* each part does, *HOW* it does it . . . we'll see how it must be *CARED FOR!*

Another analogy between medicine and maintenance: there are various types of human bodies, but if you know basic anatomy, you understand them all. The same is true of centrifugal pumps. In building one basic type, we'll learn about *ALL* types.

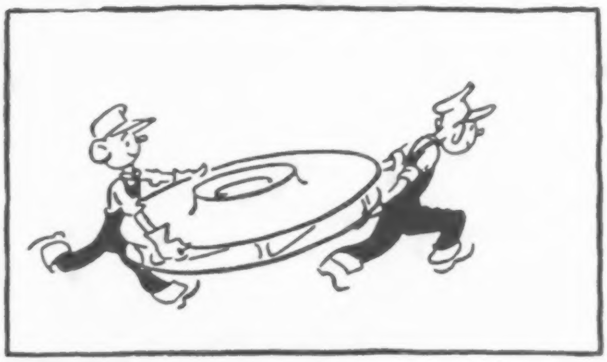
Part of this will be elementary to some maintenance people . . . but they will find it a valuable "refresher" course, and, after all, maintenance just can't be too good.

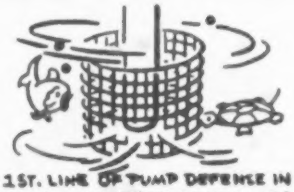
So with a side glance at the centrifugal principle on the page at the left, let's get on with building our pump. . .

FIRST WE REQUIRE A DEVICE TO SPIN LIQUID AT HIGH SPEED. . .

That paddle-wheel device is called the "impeller" . . . and it's the heart of our pump.

Note that the blades curve out from its hub. As the impeller spins, liquid between the blades is impelled outward by centrifugal force.





1ST. LINE OF PUMP DEFENSE IN WATER CARRYING STICKS, ETC!

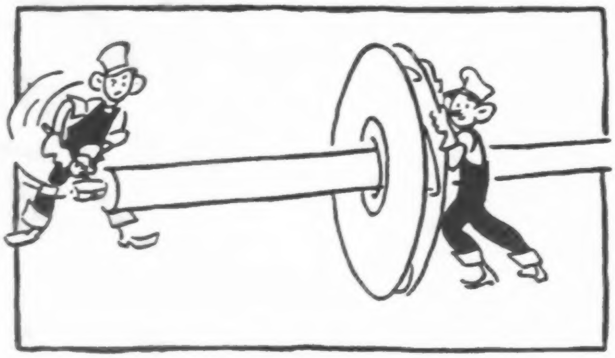
Note, too, that our impeller is open at the center — the "eye." As liquid in the impeller moves outward, it will suck more liquid in behind it through this eye . . . *PROVIDED IT'S NOT CLOGGED!*

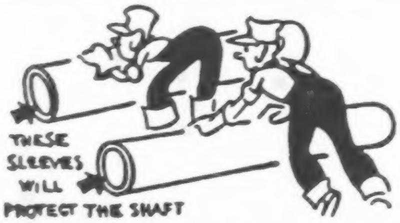
That brings up Maintenance Rule No. 1: if there's any danger that foreign matter (sticks, refuse, etc.) may be sucked into the pump — clogging or wearing the impeller unduly — *PROVIDE THE INTAKE END OF THE SUCTION PIPING WITH A SUITABLE SCREEN.*

NOW WE NEED A SHAFT TO SUPPORT AND TURN THE IMPELLER. . .

Our shaft looks heavy — and it *IS*. It must maintain the impeller in precisely the right place.

But that ruggedness does *NOT* protect the shaft from the corrosive or abrasive effects of the liquid pumped . . . so we must protect it with sleeves slid on from either end.





THESE SLEEVES WILL PROTECT THE SHAFT

What these sleeves — and the impeller, too — are made of depends on the nature of the liquid we're to pump. Generally they're bronze, but various other alloys, ceramics, glass, or even rubber-coating are sometimes required.

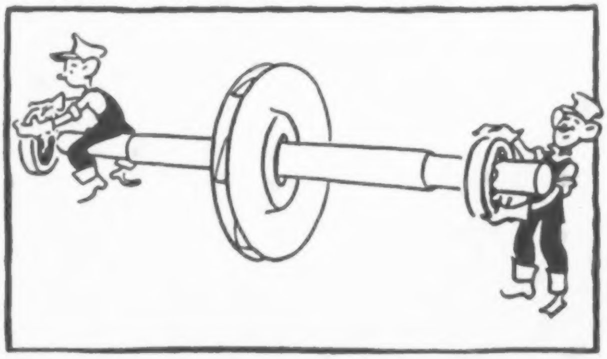
Maintenance Rule No. 2: *NEVER PUMP A LIQUID FOR WHICH THE PUMP WAS NOT DESIGNED.*

Whenever a change in pump application is contemplated and there's any doubt as to the pump's ability to resist the different liquid, *CHECK WITH YOUR PUMP MANUFACTURER!*

WE MOUNT THE SHAFT ON SLEEVE, BALL OR ROLLER BEARINGS. . .

As we'll see later, clearances between moving parts of our pumps are *QUITE SMALL.*

If bearings supporting the turning shaft and impeller are allowed to wear excessively and lower the turning units within a pump's closely-fitted mechanism, the life and efficiency of that pump will be seriously threatened.



Maintenance Rule No. 3: *KEEP THE RIGHT AMOUNT OF THE RIGHT LUBRICANT IN BEARINGS AT ALL TIMES. FOLLOW YOUR PUMP MANUFACTURER'S LUBRICATION INSTRUCTIONS TO THE LETTER.*

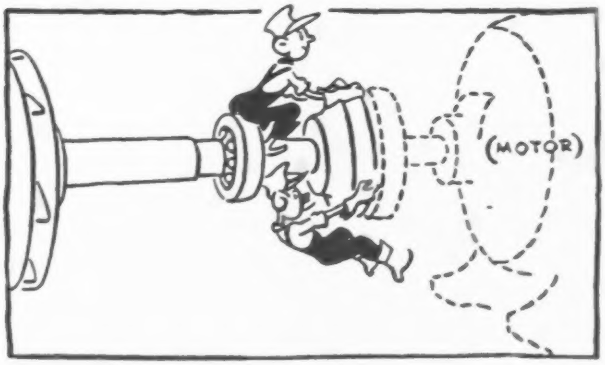
Main points to keep in mind are. . .

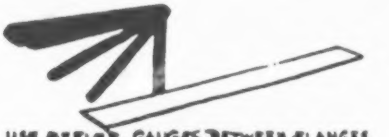
1. Although too much oil won't harm sleeve bearings, too much grease in antifriction type bearings (ball or roller) will *PROMOTE* friction and heat. Main job of grease in antifriction bearings is to protect steel elements against corrosion, not friction.
2. Operating conditions vary so widely that no one rule as to frequency of changing lubricant will fit all pumps. So play safe: if anything, change lubricant *BEFORE* it's too worn or too dirty.

TO CONNECT WITH THE MOTOR, WE ADD A COUPLING FLANGE. . .

Some pumps are built with pump and motor on one shaft, of course, and offer no alignment problem.

But our pump is to be driven by a separate motor . . . and we attach a flange to one end of the shaft through which bolts will connect with the motor flange.




USE FEELER GAUGES BETWEEN FLANGES, A STRAIGHT-EDGE ACROSS TOPS AND SIDES.

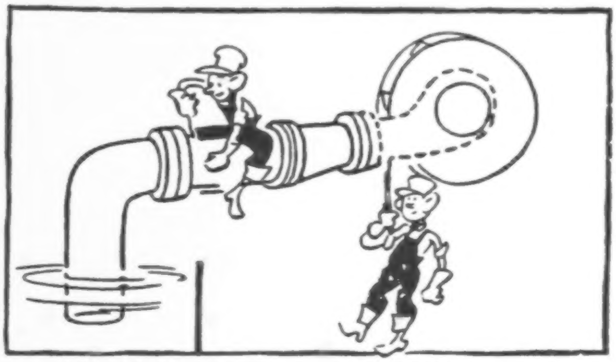
Maintenance Rule No. 4: *SEE THAT PUMP AND MOTOR FLANGES ARE PARALLEL VERTICALLY AND AXIALLY . . . AND THAT THEY'RE KEPT THAT WAY!*

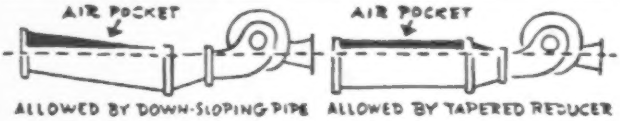
If shafts are eccentric or meet at an angle, every revolution throws tremendous extra load on bearings of both pump and motor. Flexible couplings will *NOT* correct this condition if excessive.

Checking alignment should be regular procedure in pump maintenance. Foundations can settle unevenly, piping can change pump position, bolts can loosen. Misalignment is a *MAJOR* cause of pump and coupling wear.

NOW WE NEED A "STRAW" THROUGH WHICH LIQUID CAN BE SUCKED. . .

Notice two things about the suction piping: 1) the horizontal piping slopes *UPWARD* toward the pump; 2) any reducer which connects between the pipe and pump intake nozzle should be horizontal at the top — (*ECCENTRIC*, not concentric).





This up-sloping prevents air pocketing in the top of the pipe . . . which air might be drawn into the pump and cause loss of suction.

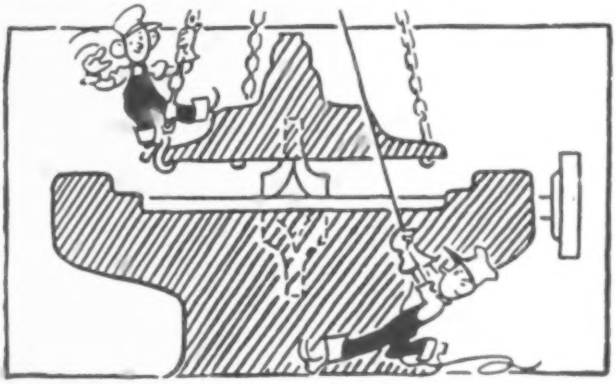
Maintenance Rule No. 5: *ANY DOWNSLOPING TOWARD THE PUMP IN SUCTION PIPING (AS EXAGGERATED IN THE DIAGRAMS ABOVE) SHOULD BE CORRECTED.*

This rule is *VERY* important. Loss of suction greatly endangers a pump . . . as we'll see shortly.

WE CONTAIN AND DIRECT THE SPINNING LIQUID WITH A CASING. . .

We got a little ahead of our story in the previous paragraphs . . . because we didn't yet have the casing to which the suction piping bolts. And the manner in which it is attached is of great importance.

Maintenance Rule No. 6: *SEE THAT PIPING PUTS ABSOLUTELY NO STRAIN ON THE PUMP CASING.*



THE WEIGHT OF PIPING CAN EASILY RUIN A PUMP!

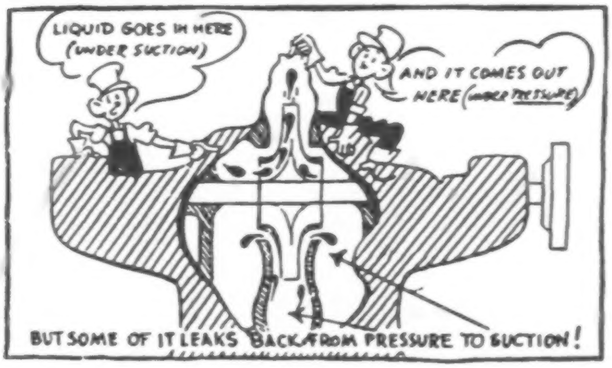
When the original installation is made, all piping should be in place and self-supporting before connection. Openings should meet with no force. Otherwise the casing is apt to be cracked . . . or sprung enough to allow closely-fitted pump parts to rub.

It's good practice to check the piping supports regularly to see that loosening, or settling of the building, hasn't put strains on the casing.

NOW OUR PUMP IS ALMOST COMPLETE, BUT IT WOULD LEAK LIKE A SIEVE. . .

We're far enough along now to trace the flow of water through our pump. It's not easy to show suction piping in the cross-section view below, so imagine it stretching from your eye to the lower center of the pump.

Our pump happens to be a "double suction" pump, which means that the water flow is divided inside the pump casing . . . reaching the eye of the impeller from either side.

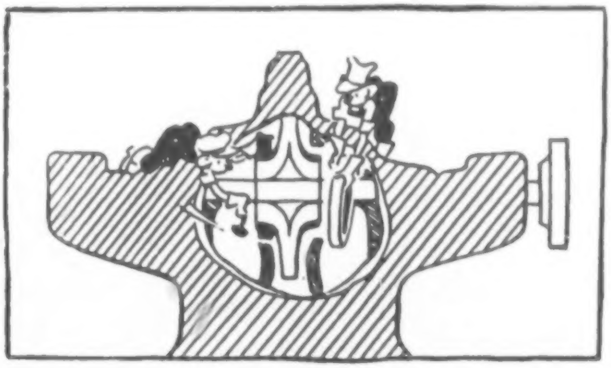

LIQUID GOES IN HERE (UNDER SUCTION)
AND IT COMES OUT HERE (UNDER PRESSURE)
BUT SOME OF IT LEAKS BACK FROM PRESSURE TO SUCTION!

As water is sucked into the spinning impeller, centrifugal force causes it to flow outward . . . building up high pressure at the outside of the pump (which will force water *OUT*) and creating low pressure at the center of the pump (which will suck water *IN*.) This situation is diagrammed in the upper half of the pump, above.

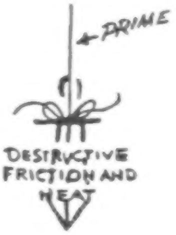
So far so good . . . except that water tends to be sucked back from pressure to suction through the space between impeller and casing — as diagrammed in the lower half of the pump, above — and our next step must be to plug this leak, if our pump is to be very efficient!

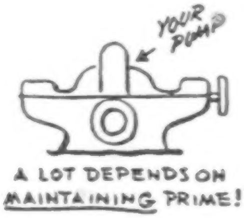
SO WE ADD WEARING RINGS TO PLUG INTERNAL LIQUID LEAKAGE. . .

You might ask why we didn't build our parts closer fitting in the first place — instead of narrowing the gap between them by inserting wearing rings.



The answer is that those rings are removable and *REPLACEABLE* . . . when wear enlarges the tiny gap between them and the impeller. (Sometimes rings are attached to impeller rather than casing — or rings are attached to *BOTH* so they face each other.)




YOUR PUMP
A LOT DEPENDS ON MAINTAINING PRIME!

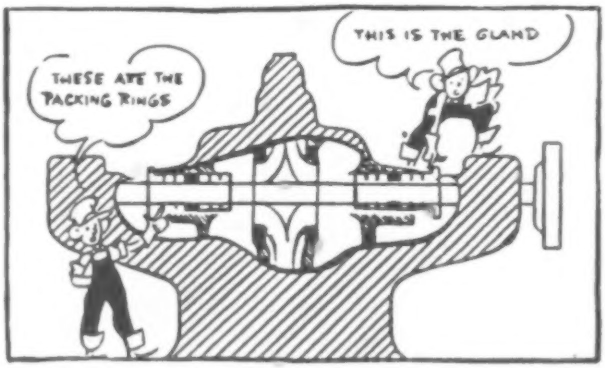
Maintenance Rule No. 7: *NEVER ALLOW A PUMP TO RUN DRY* (either through lack of proper priming when starting or through loss of suction when operating). Water is a *LUBRICANT* between rings and impeller.

Maintenance Rule No. 8: *EXAMINE WEARING RINGS AT REGULAR INTERVALS.* When seriously worn, their replacement will greatly improve pump efficiency.

TO KEEP AIR FROM BEING SUCKED IN, WE USE STUFFING BOXES. . .

We have two good reasons for wanting to keep air out of our pump: 1) we want to pump water, not air; 2) air leakage is apt to cause our pump to lose suction.

Each stuffing box we use consists of a casing, rings of packing and a gland at the outside end.


THIS IS THE GLAND
THESE ARE THE PACKING RINGS

Maintenance Rule No. 9: *PACKING SHOULD BE REPLACED PERIODICALLY — DEPENDING ON CONDITIONS — USING THE PACKING RECOMMENDED BY YOUR PUMP MANUFACTURER.* Forcing in a ring or two of new packing instead of replacing worn packing is *BAD PRACTICE.* it's apt to displace the seal cage (see next page).

Put each ring of packing in separately, seating it firmly before adding the next. Stagger adjacent rings so the points where their ends meet do not coincide.

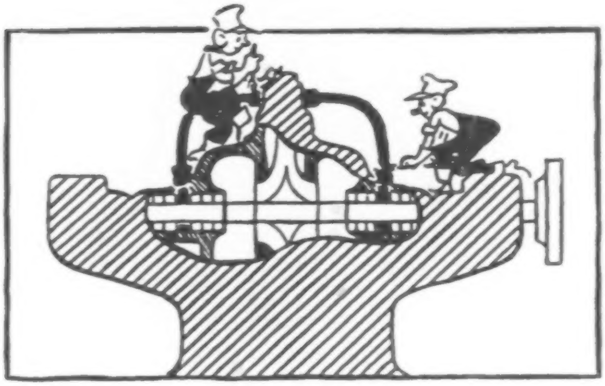
Maintenance Rule No. 10: *NEVER TIGHTEN A GLAND MORE THAN NECESSARY* . . . as excessive pressure will wear shaft sleeves unduly.

Maintenance Rule No. 11: *IF SHAFT SLEEVES ARE BADLY SCORED, REPLACE THEM IMMEDIATELY* . . . or packing life will be entirely too short.

TO MAKE A PACKING MORE AIR-TIGHT, WE ADD WATER SEAL PIPING. . .

In the center of each stuffing box is a "seal cage." By connecting it with piping to a point near the impeller rim, we bring liquid *UNDER PRESSURE* to the stuffing box.

This liquid acts both to block out air intake and to lubricate the packing. It makes both packing and shaft sleeves wear longer . . . *PROVIDING IT'S CLEAN LIQUID!*



WATER IS A LUBRICANT!

Maintenance Rule No. 12: *IF THE LIQUID BEING PUMPED CONTAINS GRIT, A SEPARATE SOURCE OF SEALING LIQUID SHOULD BE OBTAINED* (e.g. it may be possible to direct some of the pumped liquid into a container and settle the grit out).

To control liquid flow, draw up the gland just tight enough so a *THIN* stream flows from the stuffing box during pump operation.

DISCHARGE PIPING COMPLETES THE PUMP INSTALLATION — AND NOW WE CAN ANALYZE THE VARIOUS FORCES WE'RE DEALING WITH. . .

SUCTION. At least 75% of centrifugal pump troubles trace to the suction side. To minimize them . . .

1. Total suction lift (distance between center line of pump and liquid level when pumping, plus friction losses) generally should not exceed 15 feet.
2. Piping should be at least a size larger than pump suction nozzle.
3. Friction in piping should be minimized . . . use as few and as easy bends as possible . . . avoid scaled or corroded pipe.

DISCHARGE lift, plus suction lift, plus friction in the piping from the point where liquid enters the suction piping to the end of the discharge piping equals total head.

PUMPS SHOULD BE OPERATED NEAR THEIR RATED HEADS.

Otherwise, pump is apt to operate under unsatisfactory and unstable conditions which reduce efficiency and operating life of the unit.

Note the description of "cavitation" on next page and directions for figuring the head your pumps are working against.

PUMP CAPACITY generally is measured in gallons per minute. A new pump is guaranteed to deliver its rating in capacity and head.

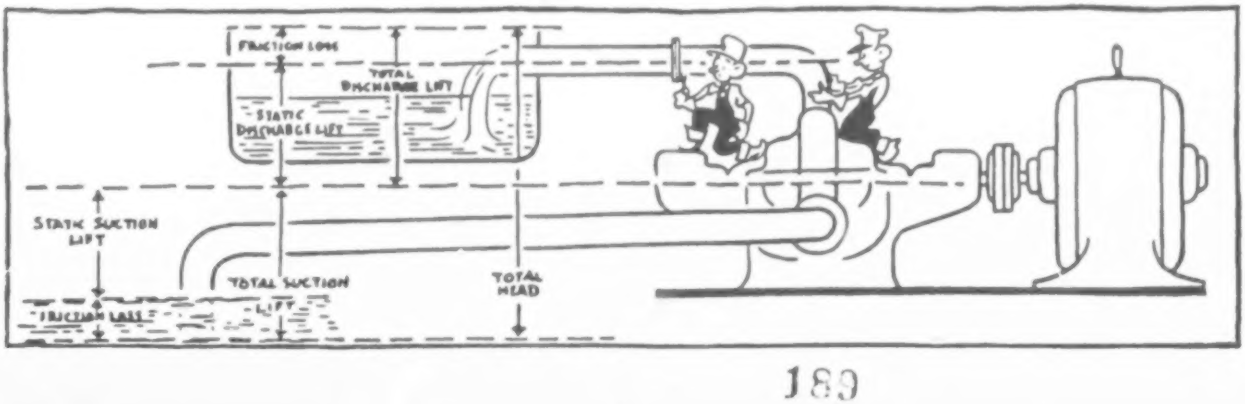
But whether a pump *RETAINS* its actual capacity depends to a great extent on its maintenance.

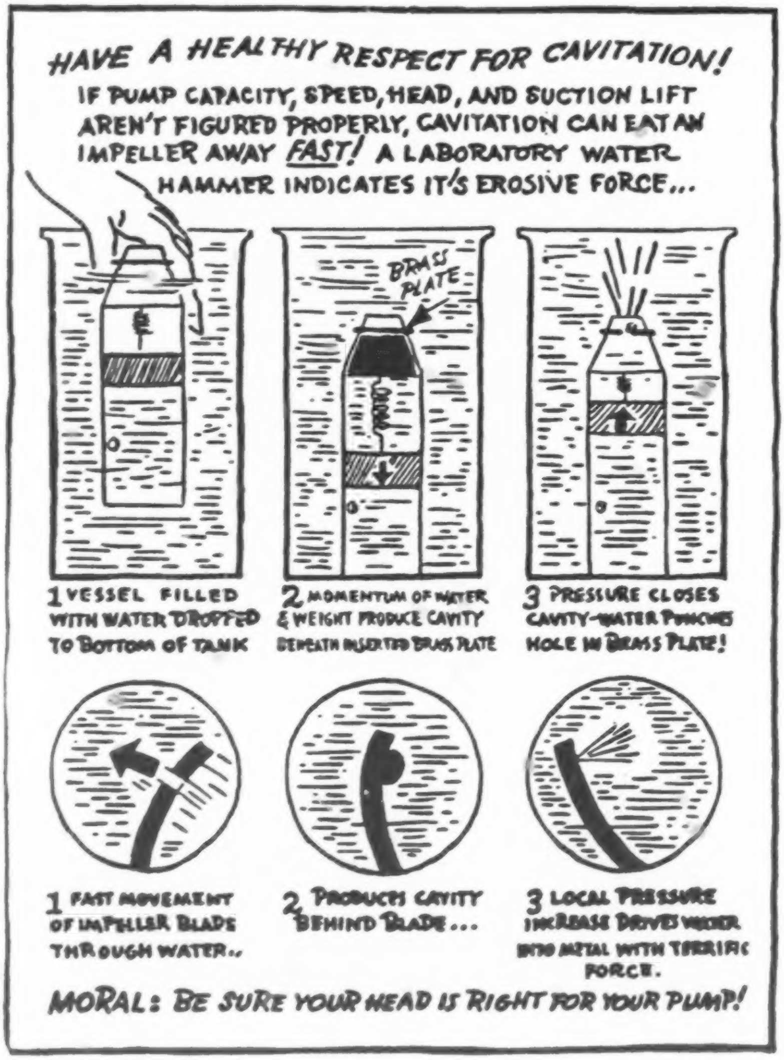
Wearing rings must be replaced when necessary — to keep internal leakage losses down.

Friction must be minimized in bearings and stuffing boxes by proper lubrication . . . and misalignment must not be allowed to force scraping between closely-fitted pump parts.

POWER of the driving motor, like capacity of the pump, will not remain at a constant level without proper maintenance. (If you use electric motors, by all means send for Allis-Chalmers free "Guide to Care of Electric Motors"!)

Starting load on motors can be reduced by throttling or closing the pump discharge valve (*NEVER* the suction valve!) . . . but the pump must not be operated for long with the discharge valve closed. Power then is converted into friction — overheating the water with serious consequences.




HAVE A HEALTHY RESPECT FOR CAVITATION!
IF PUMP CAPACITY, SPEED, HEAD, AND SUCTION LIFT AREN'T FIGURED PROPERLY, CAVITATION CAN EAT AN IMPELLER AWAY FAST! A LABORATORY WATER HAMMER INDICATES IT'S EROSIVE FORCE...
BRASS PLATE
1 VESSEL FILLED WITH WATER DROPPED TO BOTTOM OF TANK
2 MOMENTUM OF WATER & WEIGHT PRODUCE CAVITY BENEATH INSERTED BRASS PLATE
3 PRESSURE CLOSES CAVITY—WATER PUNCHES HOLE IN BRASS PLATE!
1 FAST MOVEMENT OF IMPELLER BLADE THROUGH WATER..
2 PRODUCES CAVITY BEHIND BLADE...
3 LOCAL PRESSURE INCREASE DRIVES WATER INTO METAL WITH TERRIFIC FORCE.
MORAL: BE SURE YOUR HEAD IS RIGHT FOR YOUR PUMP!

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 229.

9.41A What are some uses of pumps?

9.41B Why is it important to know how a pump is built?

9.41C When should pump lubricants be changed?

9.41D How can you determine if a pump is in proper alignment?

9.41E Why must horizontal suction lift piping always slope upward towards the pump?

9.41F How can piping be prevented from putting a strain on the pump casing?

9.41G Why should a pump never be allowed to run dry?

9.42 Pump Types and Parts

After understanding the pump construction, you notice that there are several components and parts. Most of these are similar in construction, material, and location in all manufacturers' pumps. To help you find the location of the different parts and troubleshoot pumps that don't perform properly, the following figures show cut-away views of different types of pumps, and the location and name of the pump parts.

1. Figure 9.18	Horizontal Non-Clog Wastewater Pump with Open Impeller
2. Figure 9.19	Vertical Ball-Bearing Type Wastewater Pump
3. Figure 9.20	Propeller Pump
4. Figure 9.21	Incline Screw Pump
5. Figure 9.22	Pneumatic Ejector
6. Figure 9.23	Piston Pump on High Velocity Cleaner
7. Figure 9.24	Submersible Wastewater Pump
8. Figure 9.28	Diaphragm (Pneumatic) Pump
9. Figure 9.29	Diaphragm (Pneumatic) Pump

Every manufacturer has an operation, maintenance, and repair manual for their particular pump. These manuals contain installation instruction, start-up procedures, operation information, maintenance program, lubrication schedules, repair procedures, parts list, and other valuable information. These should be in the file for each pump in your system. If you need a brochure for a particular pump, ask your salesman, supplier, or write to the manufacturer. Very seldom is there a charge for these manuals, but, if so, it is minimal and well worth the investment.

9.421 Centrifugal Pumps

Figures 9.18 through 9.20 illustrate different types of centrifugal pumps.

9.422 Screw Pumps (Fig. 9.21)

Screw pumps are another type of pump used to lift wastewater to a higher elevation. This pump consists of a screw operating at a constant speed within a housing or trough. The screw has a pitch and is set at a specific angle. When revolving, it conveys the wastewater up the trough to a discharge point. The discharge is usually a free discharge. The screw is constructed of a steel tube with flights welded around it and looks very similar to a screw conveyor. The trough can be either steel or concrete depending upon size of screw and preference.

The screw is supported by two bearings, one at the top and one on the bottom. The upper bearing is generally a ball or roller bearing, and the lower bearing is a sleeve bearing designed for underwater service. The bearings must be lubricated according to manufacturer's recommendations. If either bearing fails, it must be replaced immediately before the screw rubs on the trough and causes damage.

Screw pumps are usually driven by helical (spiral) gear speed reducers powered by electric motors. The speed reducers must be filled with a proper oil recommended by the equipment manufacturer. The oil level should be checked according to manufacturer's recommendations, such as a weekly measurement and changed at least every six months.

Screw pumps should be inspected daily for bent flights, unusual noises, and general operating condition.

Screw pumps have fairly high maximum operating efficiencies, ranging as high as 75 to 80 percent. A unique characteristic is that they generally do not lose more than 10 to 15 pecent of the maximum efficiency throughout the entire 85 to 90 percent of their upper capacity pumping range. They are a constant-speed pump which has the capabilty to pump from no-flow to maximum flow directly dependent upon the rate of incoming flow to the lower end of the screw. Greater pumping rates are the result of increased submergence which will occur when higher flows are present, and lesser pumping rates are achieved by just the opposite conditions. Screw pumps are capable of handling large solids and rags without plugging. Wherever these pumps are installed, proper hand rails, guards, and barriers should be installed to protect operators and equipment from entering the pumping area. Special precautions must be taken to avoid problems caused by splashing on trough sidewalls and steps. Good cleanup procedures are needed to avoid a slippery and odorous mess.

An anti-reverse rotational back stop is usually incorporated in the gear reducer to prevent the liquid trapped in the screw from driving it in the reverse direction when it runs back down the trough at the time of power cut-off.

WARNING

Before working on any part of this pump, be sure the electrical panel is tagged off and the motor main breaker is locked out.

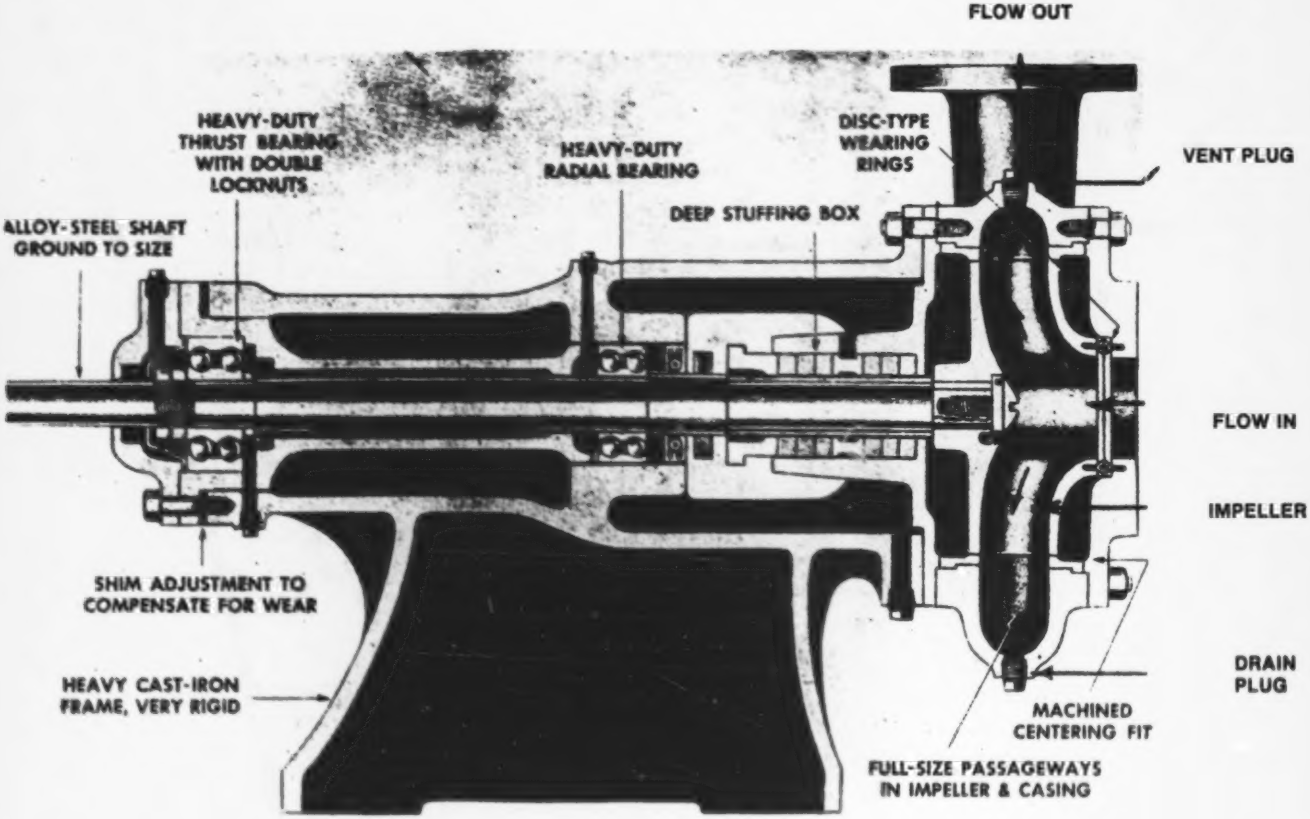

FLOW OUT
HEAVY-DUTY THRUST BEARING WITH DOUBLE LOCKNUTS
HEAVY-DUTY RADIAL BEARING
DISC-TYPE WEARING RINGS
VENT PLUG
ALLOY-STEEL SHAFT GROUND TO SIZE
DEEP STUFFING BOX
FLOW IN
IMPELLER
SHIM ADJUSTMENT TO COMPENSATE FOR WEAR
DRAIN PLUG
HEAVY CAST-IRON FRAME, VERY RIGID
MACHINED CENTERING FIT
FULL-SIZE PASSAGEWAYS IN IMPELLER & CASING

Fig. 9.18 Horizontal non-clog wastewater pump with open impeller

(Source: War Department Technical Manual TM5-666)

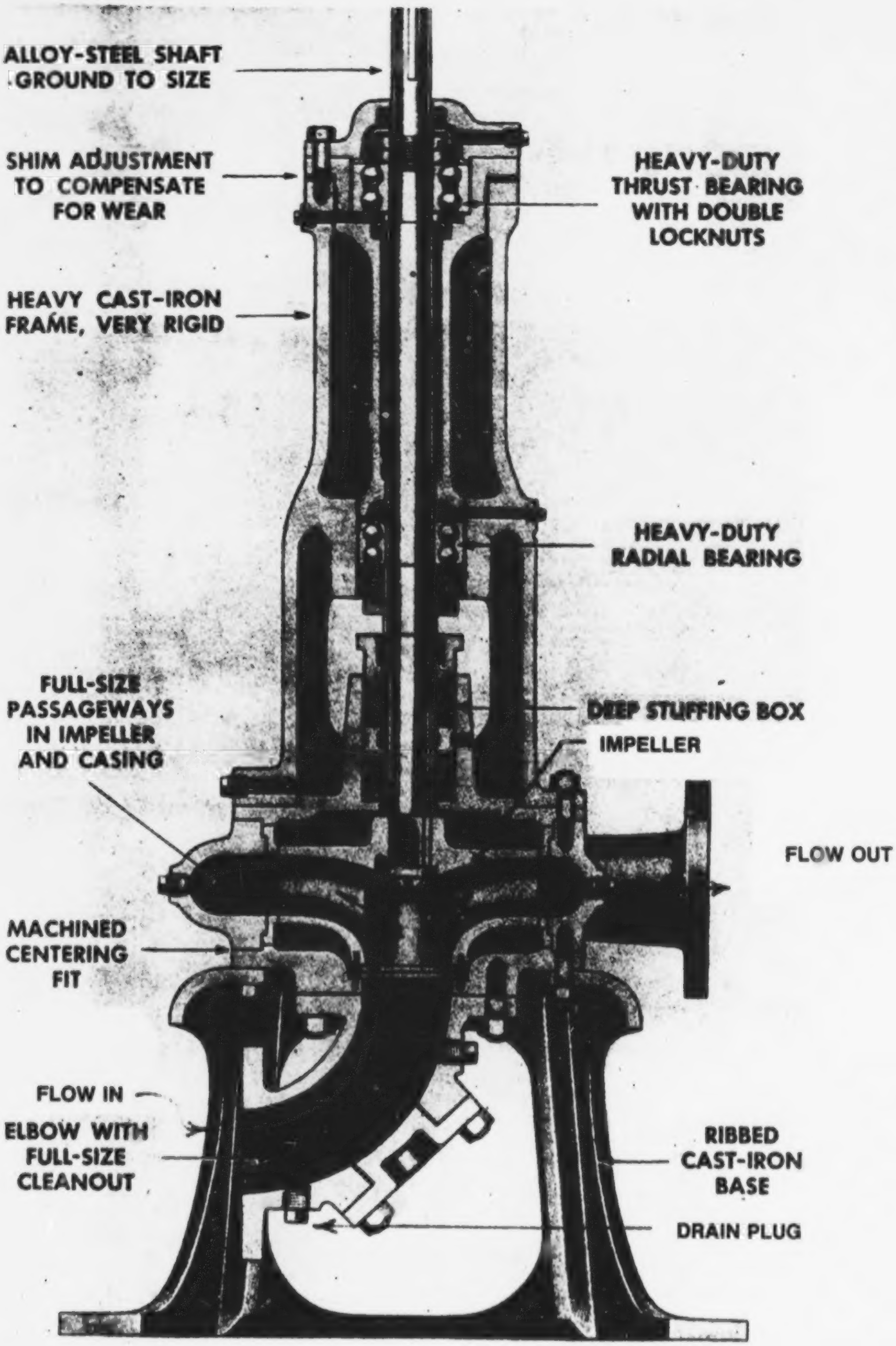

ALLOY-STEEL SHAFT GROUND TO SIZE
SHIM ADJUSTMENT TO COMPENSATE FOR WEAR
HEAVY-DUTY THRUST BEARING WITH DOUBLE LOCKNUTS
HEAVY CAST-IRON FRAME, VERY RIGID
HEAVY-DUTY RADIAL BEARING
FULL-SIZE PASSAGEWAYS IN IMPELLER AND CASING
DEEP STUFFING BOX
IMPELLER
FLOW OUT
MACHINED CENTERING FIT
FLOW IN
ELBOW WITH FULL-SIZE CLEANOUT
RIBBED CAST-IRON BASE
DRAIN PLUG

Fig. 9.19 Vertical ball-bearing type wastewater pump

(Source: War Department Technical Manual TM5-666)

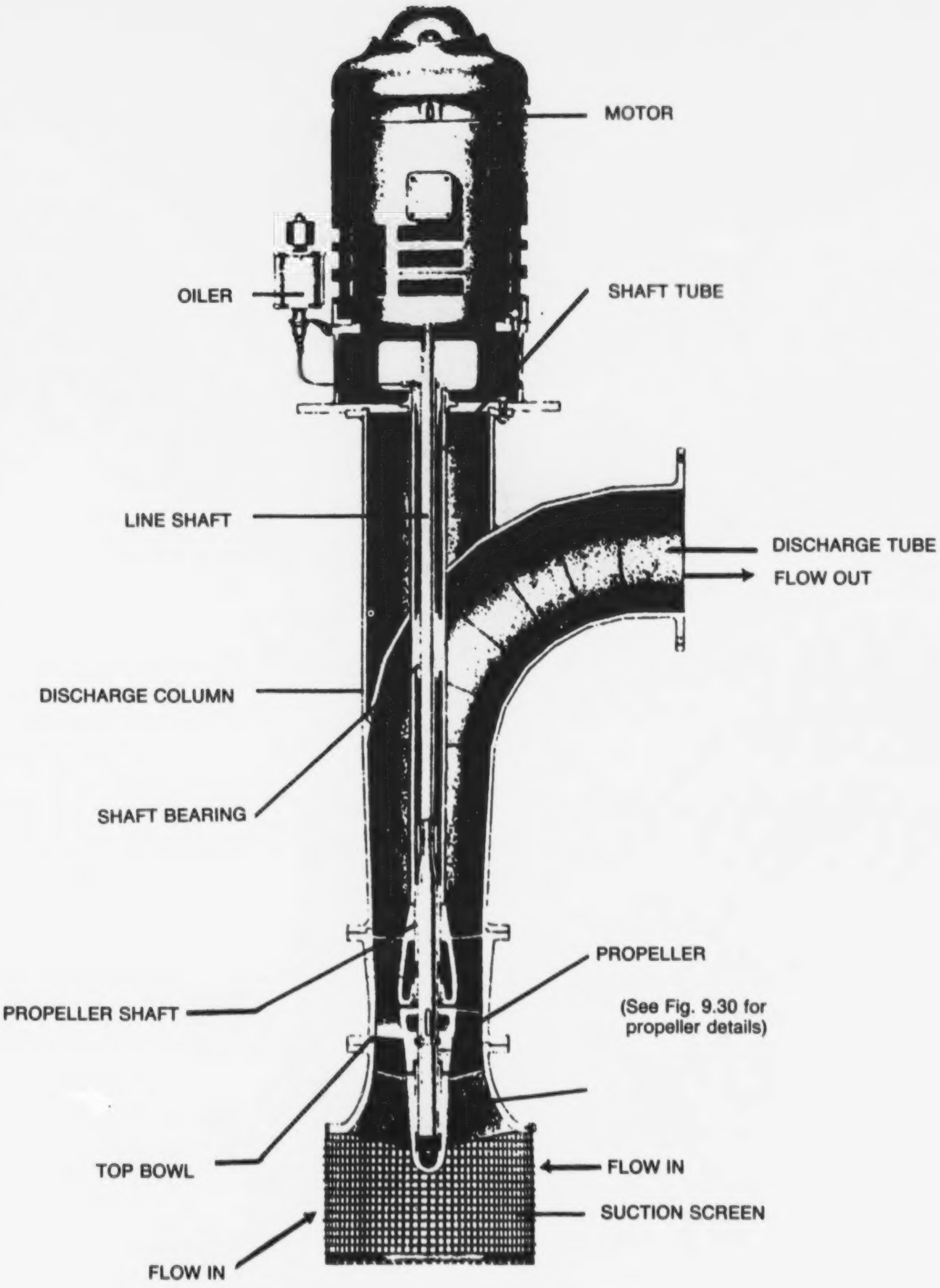

MOTOR
OILER
SHAFT TUBE
LINE SHAFT
DISCHARGE TUBE
FLOW OUT
DISCHARGE COLUMN
SHAFT BEARING
PROPELLER
(See Fig. 9.30 for propeller details)
PROPELLER SHAFT
TOP BOWL
FLOW IN
SUCTION SCREEN
FLOW IN

Fig. 9.20 Propeller pump

(Source: Unknown)

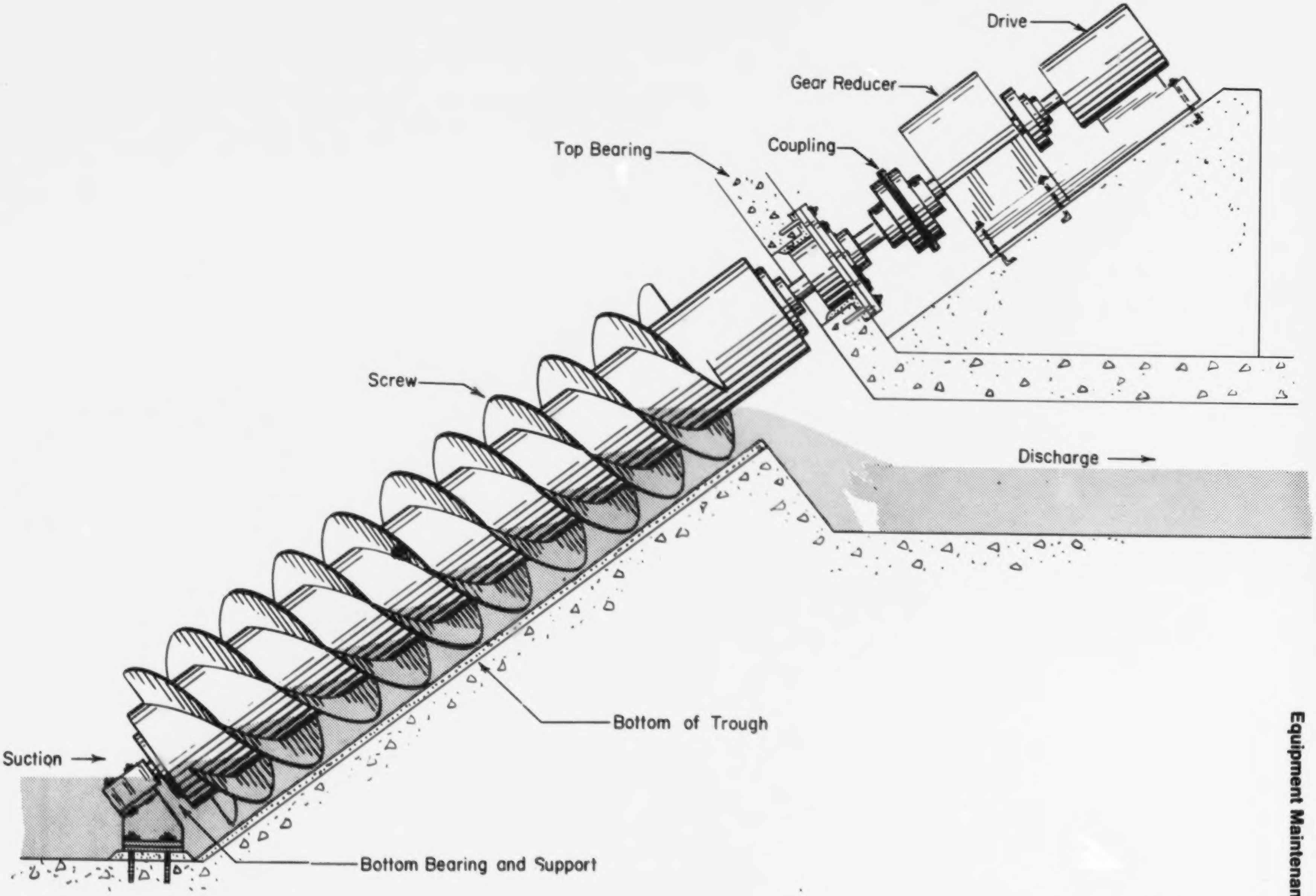

Drive
Gear Reducer
Coupling
Top Bearing
Screw
Discharge
Bottom of Trough
Suction
Bottom Bearing and Support

Fig. 9.21 Incline screw pump

(Courtesy of FMC Corporation, Environmental Equipment Division)

9.423 Pneumatic Ejectors (Fig. 9.22)

Pneumatic ejectors are used when it is necessary to handle limited or low flows with relatively large solids. Centrifugal pumps are highly efficient for pumping large flows; however, when scaled down for lower flows, they tend to plug easily. There is a restriction of flow in a centrifugal pump because the impeller opening is too small to pass unstrained solids. Pneumatic ejectors, on the other hand, are capable of passing solids up to the size of the inlet and discharge valves, and there is nothing on the inside of the ejector-receiver to restrict the flow.

The pneumatic ejector is a clean, reliable device for pumping wastewater. The ejector consists simply of two check valves, an air valve, and a receiver or tank. Wastewater flows into the receiver by gravity. When the ejector is filled, a control admits compressed air to force out the wastewater in the receiver.

Pneumatic ejector systems fall into four categories:

1. Tankless System. A compressor with no intermediate air tank is supplied with each ejector, and starts each time the unit is filled.
2. Package System. This is an ejector with the compressor mounted above the receiver and without an air storage tank. The controls and compressor are prewired and mounted at the factory.
3. Stored Air System. In this system, an air tank is used between the compressor and the ejector. This arrangement has the advantage that more than one compressor can be used for standby.
4. Plant Air System. If an ample supply of air is available from a wastewater treatment plant, this air can be used rather than installing another air compressor.

The pneumatic ejector has a built-in level control device that produces an intermittent discharge. This control is either electrically or pneumatically operated, depending on the job requirements.

Maintenance of pneumatic ejectors is not as complicated as maintenance of most pumps; however, maintenance must be performed when scheduled. Clean the interior of the pots to remove grease. Inspect valves, floats and/or electrical controls for proper operation. If a failure occurs and wastewater enters the air lines or air control valves, dismantle and clean. The motor and air compressor require regular preventive maintenance and overhaul.

OPERATION PROBLEM CHECKLIST

Ejector Will Not Discharge

Cause:	Procedure and Cure:
1. Ejector not filling	Inlet gate valve and check valve closed or plugged. Open and/or clean.
2. Insufficient air pressure or volume	One psi of pressure for each 2 feet of discharge head is the minimum air pressure needed for discharge. The amount of air determines the discharge time. Remember that the inlet check valve is closed during discharge.
3. Pilot valve not functioning	A. Counterweight must be in the down position to discharge ejector. The counterweight is a weight on the end of a lever on the check valve that helps the check valve operate properly. B. Accumulation of grease and foreign matter on upper bell preventing proper travel to shift the pilot valve. Check top of bell and clean as necessary through access opening in wastewater receiver. C. Check air supply.
4. Strainer and air line to receiver plugged	Remove and clean.
5. Discharge gate or check valve closed or plugged	Open and clean.
6. Discharge line plugged	Hand rod discharge line.
7. Counterweight stuck	Packing too tight. Loosen and finger-tighten only.
8. Grease on probes	Clean probes.
9. Faulty switching circuit	Find cause of problem and repair.

Short Cycling of Pneumatic Ejector

Cause:	Procedure and Cure:
1. Inlet check valve leaks and allows liquid to be pumped back into low level manhole causing excess head in manhole	Inspect check valve for foreign matter under valve seat and/or worn seat. Remove, and/or replace.
2. Discharge check valve leaks permitting liquid discharged to flow back to the ejector receiver	Same as above except for discharge check valve.
3. Counterweight too close to guide	Adjust counterweight out farther on the lever arm.
4. Packing around float linkage too loose	Finger-tighten packing and check adjustment of counterweight.

Ejector Will Not Fill

Cause:	Procedure and Cure:
1. Inlet check valve or gate valve closed or clogged	Open and clean.
2. Strainer between main valve and receiver clogged and preventing venting of receiver	Clean or replace screen.
3. Air exhaust line clogged	Clean.
4. Sewer plugged upstream from ejector	Clear sewer.
5. No flow in sewer	Discharge water from water truck or fire hydrant into upstream manhole when you wish to operate ejector.

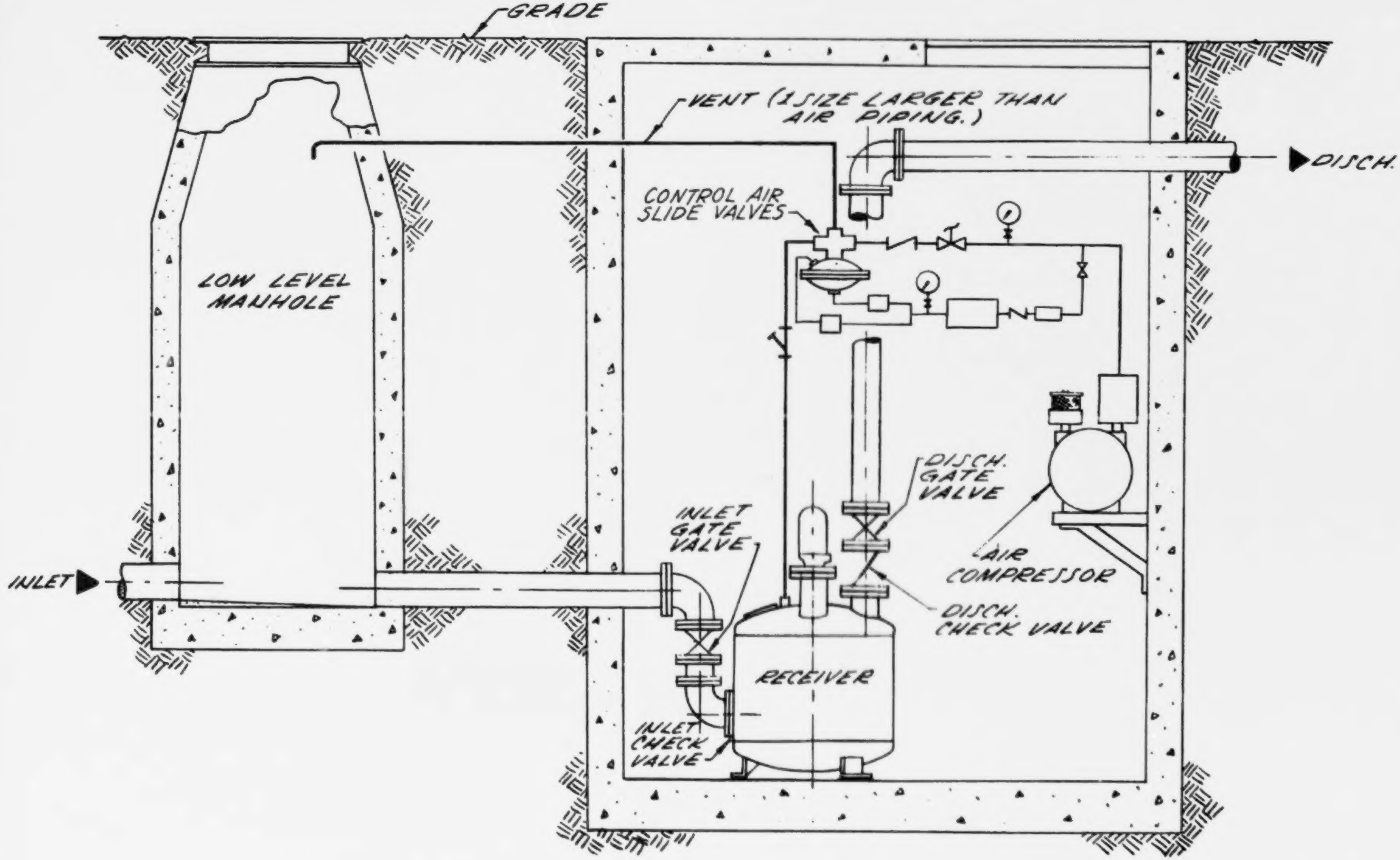

GRADE
VENT (1 SIZE LARGER THAN AIR PIPING.)
DISCH.
CONTROL AIR SLIDE VALVES
LOW LEVEL MANHOLE
DISCH. GATE VALVE
INLET GATE VALVE
AIR COMPRESSOR
INLET
DISCH. CHECK VALVE
RECEIVER
INLET CHECK VALVE

Fig. 9.22 Pneumatic ejector system
(Courtesy of James Equipment and Manufacturing Company)

RECOMMENDED PREVENTIVE MAINTENANCE SCHEDULE

DAILY: Observe several cycles assuring that counterweight action is proper.

WEEKLY: Hold down counterweight approximately 2 to 3 minutes and check general operation.

QUARTERLY: Inspect operation of all gate and globe valves.

SEMI-ANNUALLY: Clean air strainer between ejector receiver and main air valve.

ANNUALLY: General inspection of all equipment, cleaning and painting all items as necessary.

Every five years, open 6-inch inspection opening on ejector receiver. Inspect and clean as necessary. Examine inlet and discharge check valves, main air valve and pilot valve.

9.424 Piston Pumps (Fig. 9.23)

Piston pumps are commonly used in high velocity cleaners. The maintenance operator will be required to operate, maintain, and service these pumps. Piston pumps, no matter what manufacturer, operate on the same principle. There is a fluid cylinder, piston, intake valve, and discharge valve. The piston is connected by a rod to a crankshaft. As the crankshaft is turned in a vertical cylinder, the piston travels to the bottom of the fluid cylinder. When this happens, it draws water into the fluid cylinder due to the negative pressure. As the piston travels to the top, it pushes or pumps the water out the discharge valve. A pump may have two fluid cylinders (duplex), three fluid cylinders (triplex), four fluid cylinders (quadruplex), or five fluid cylinders (quintuplex) and the cylinders may be mounted either horizontally or vertically. The number of fluid cylinders varies with pressure and gallons per minute needed.

Three other factors also determine the pump capacity — the number of strokes per minute, length of stroke, and diameter of piston or plunger. The larger piston allows more water to enter, and the "Speed" gives it more strokes per minute, therefore, pumping more water. Unlike a centrifugal pump, the pressure is not determined by the speed. A piston pump is a positive displacement pump. This means that what enters the pump on the suction stroke must be discharged on the discharge stroke, if the valves open and close properly. Because of this, *THE DISCHARGE VALVE ON AN OPERATING PISTON PUMP MUST NEVER BE CLOSED.* If it is, the pressure will continue to build until the engine is stalled or something breaks. The pressure developed by a piston pump depends on the size of the piston, the force applied to the piston, and the lack of leakage around the valves. Piston pumps should have suction lines at least as large as the pump suction.

On the discharge side of the pump there is a relief valve. This is installed to protect pumps from failure due to excessive pressure. Flows are usually by-passed back to the suction side of the pump when excessive pressures develop. This relief valve must be set according to factory specifications for each particular pump. Failure to have a properly set relief valve can result in loss of life, property, or irreparable damage. Also located on the pump is a pulsation dampener. This is a precharged unit designed to take out the shock of pulsations by the use of an air pocket when the pump is operating. This unit provides longer life to valves, valve springs, and plungers with reduced surges.

Piston pumps also have packing, although it is not usually a problem. They use a hard core packing that must be kept tight at all times and lubricated. The packing is usually greased daily with a lithium-base grease, or with water pump grease. Use a manually operated grease gun. If a pressure grease gun is used, the pressure can become too great and you could lose the packing seals. Some pumps of this type are equipped with force feed oilers, and these must be kept full. A universal-type packing is sometimes used, and this type packing must be installed so the lips of each sealing ring face the fluid pressure.

Disc or flap valves and valve springs should be inspected periodically for wear. These valves usually consist of a valve seat, valve disc, and spring. The valves can be replaced in most models of pumps, although special tools are required. By removing the valve cover plug, the valves can be inspected. Look for broken springs; worn, bent, or broken discs; or seat faces which are corroded, cut, or grooved. Sometimes the discs can be flipped over when worn excessively on one side. Seat faces may show uniform wear and still be satisfactory. The springs and discs are usually easily replaced, but seats require special pullers, *MANDRELS*[6] and tools. If you replace seats, take special care not to damage the seating face. This can be done by using an old disc in position over the new seat when tapping it back into the pump body. Valve replacement or repair will be necessary when loss of pressure, volume, or an unusual knocking is noticed.

The crankshaft, pistons, rods, and other parts of the piston pump usually don't cause problems when properly used and maintained. To completely overhaul the pump, each manufacturer's literature must be followed. This requires a high degree of mechanical aptitude and experience, and is not generally done by the maintenance operator.

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[6] *Mandrel (MAN-drill). A special tool used to push bearings in or to pull sleeves out.*

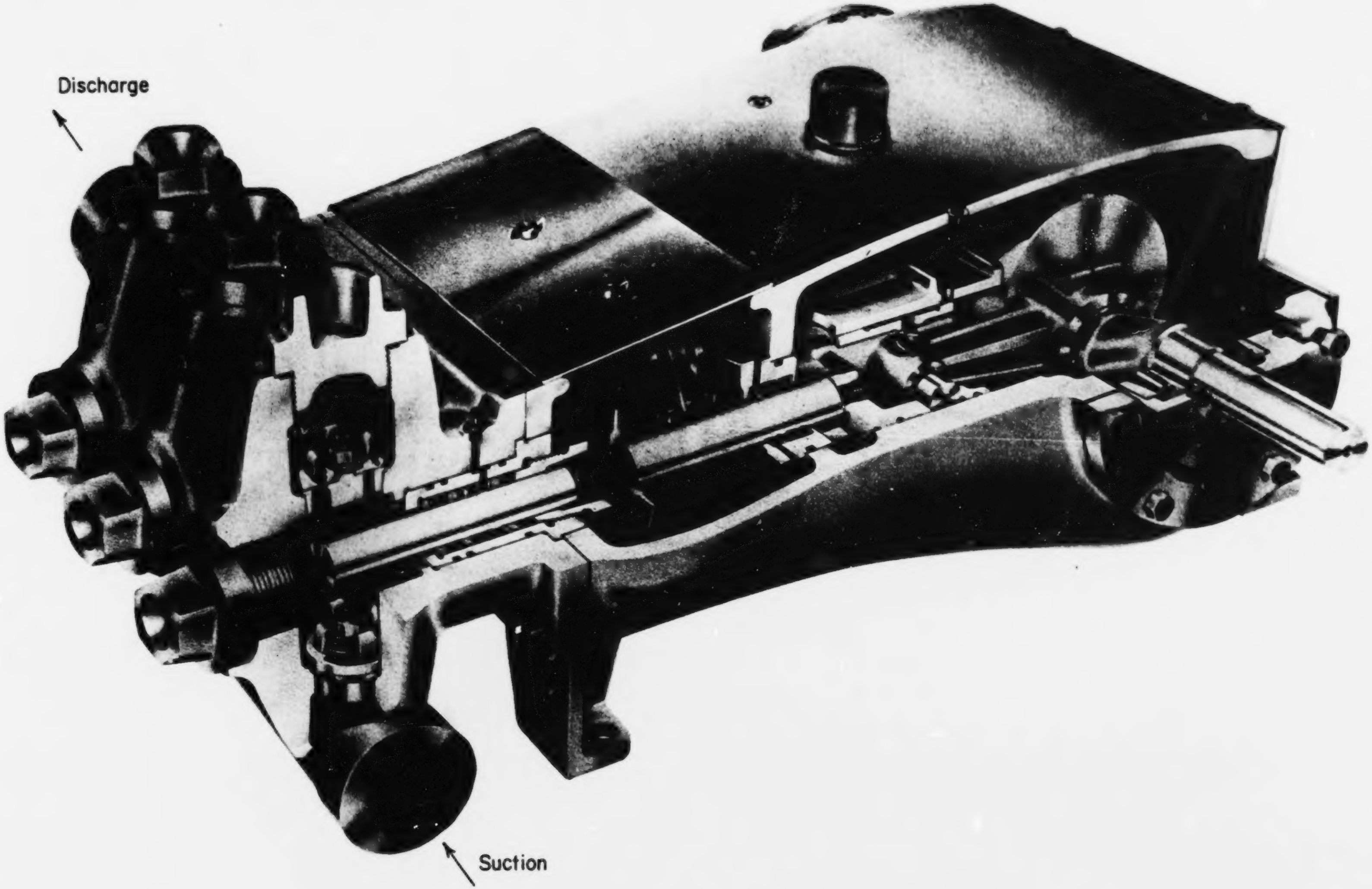

Discharge
Suction

Fig. 9.23 Piston pump on high-velocity cleaner

(Courtesy Wheatley Company, Tulsa, Oklahoma)

201 202

Maintenance required on piston pumps:

DAILY 1. Determine oil level in crankcase,
2. Lubricate packing,
3. Inspect packing for leakage, and
4. Keep pump clean.

MONTHLY 1. Wash crankcase filter,
2. Inspect and tighten all nuts and bolts, if needed,
3. Inspect gaskets for oil leaks, and
4. Thoroughly observe operation of all equipment.

SEMI-ANNUALLY 1. Change oil in crankcase,
2. Inspect valves,
3. Inspect for excessive play in crankshaft bearings and connecting rod bearings, and
4. Clean and touch up paint.

Each manufacturer has lubrication and maintenance brochures and these must be followed for your particular pump.

9.425 Close-Coupled Pumps

Close-coupled pumps differ from the other pumps because the motor and pump are one unit. The motor has an extended shaft and has provisions for mounting the volute surrounding the impeller on the end of the motor. The extended shaft has the impeller mounted on it. On this type of pump there is only one shaft which is the motor shaft; therefore, there isn't any coupling. The pump is running at the same speed as the motor.

The advantages of this pump include the fact that the size permits installation in tight spaces, and it is less expensive than a motor and a pump. Some common uses of close-coupled pumps are in fresh water systems, recirculating water systems and hot water systems.

Close-coupled pumps may have packed or mechanical seals. Mechanical seals probably are more prevalent. These types of pumps are supported by the motor bearings so the only lubrication needed is on the motor. Some of these pumps have three points of lubrication. A lubrication point at each end of the motor and one point on the packing. When working on these pumps, special care must be taken to keep the mating flanges clean when assembling so the shaft is properly installed in the housing.

Some of the limitations of this pump are:

1. If the shaft is scored on the pump and can't be repaired, a rotor for the motor must be purchased since it is all one piece,
2. Some smaller motor shafts can be forced out and a new shaft must be installed, and
3. Costs for disassembly and reassembly of damaged motor are more than costs of new pump and motor.

9.426 Submersible Pumps (Fig. 9.24)

The submersible pump is similar to the close-coupled pump in many ways. The motor used is waterproof and mechanical seals are used for keeping out the water being pumped. This pump is completely submersed in the liquid being pumped, and also uses this liquid for cooling the motor. Some older installations require water over the motor at all times. New submersible pumps have thermal switches embedded in the windings to shut off the pump if it gets too hot. These thermal switches must be connected into the control circuit for this purpose.

Submersible pumps need very little daily maintenance. Since they are submerged in water, you cannot easily get to them for cleaning. They all have mechanical seals so there isn't any packing adjustment. If they become plugged with rags or debris, usually the pump has to be removed from the pit. Some of the newer submersible installations have lifting mechanisms and slide fittings on the discharge so they can be removed without pumping the wet well empty.

One of the limitations with submersible pumps is burn out of the motors. When the mechanical seal starts leaking, water can enter the motor and cause a motor burn out. Repair is very expensive. Proper preventive maintenance can prevent motor burn out and includes the items listed below.

1. Megger the motor monthly to see if moisture is entering.
2. If the submersible pump ever trips the main circuit breaker, do not reset it until cause is found.
3. Remove the submersible pump on a regular interval and replace the mechanical seal before it fails.
4. Keep grit in wet well to a minimum to reduce wear. Bucket out the grit on a weekly basis if necessary.
5. Take amperage tests every three months to determine if pump is starting to overload. Higher than normal amperage readings can indicate an overload.
6. If the motor operates in an oil bath and has an inspection plug, be sure that the bath is full of oil and not an oil-water emulsion. If the oil is emulsified, the seals are leaking. When this happens, the seals and bearings need attention.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 229.

9.42A List three types of centrifugal pumps.

9.42B How does a screw pump work?

9.42C Under what conditions would a pneumatic ejector be used?

9.42D What type of pump is used in a high-velocity cleaner?

1. LIFTING HANDLE
2. JUNCTION CHAMBER WITH WATERTIGHT CABLE ENTRIES
3. ANTI-FRICTION BEARINGS
4. SHAFT
5. STATOR WITH TEMPERATURE-SENSING THERMISTORS
6. ROTOR
7. STATOR HOUSING LEAKAGE SENSOR
8. BRG. TEMPERATURE THERMISTOR
9. SHAFT SEAL
10. OIL CHAMBER
11. VOLUTE
12. NON-CLOG IMPELLER
13. COOLING JACKET
14. SLIDING BRACKET
15. AUTOMATIC DISCHARGE CONNECTION

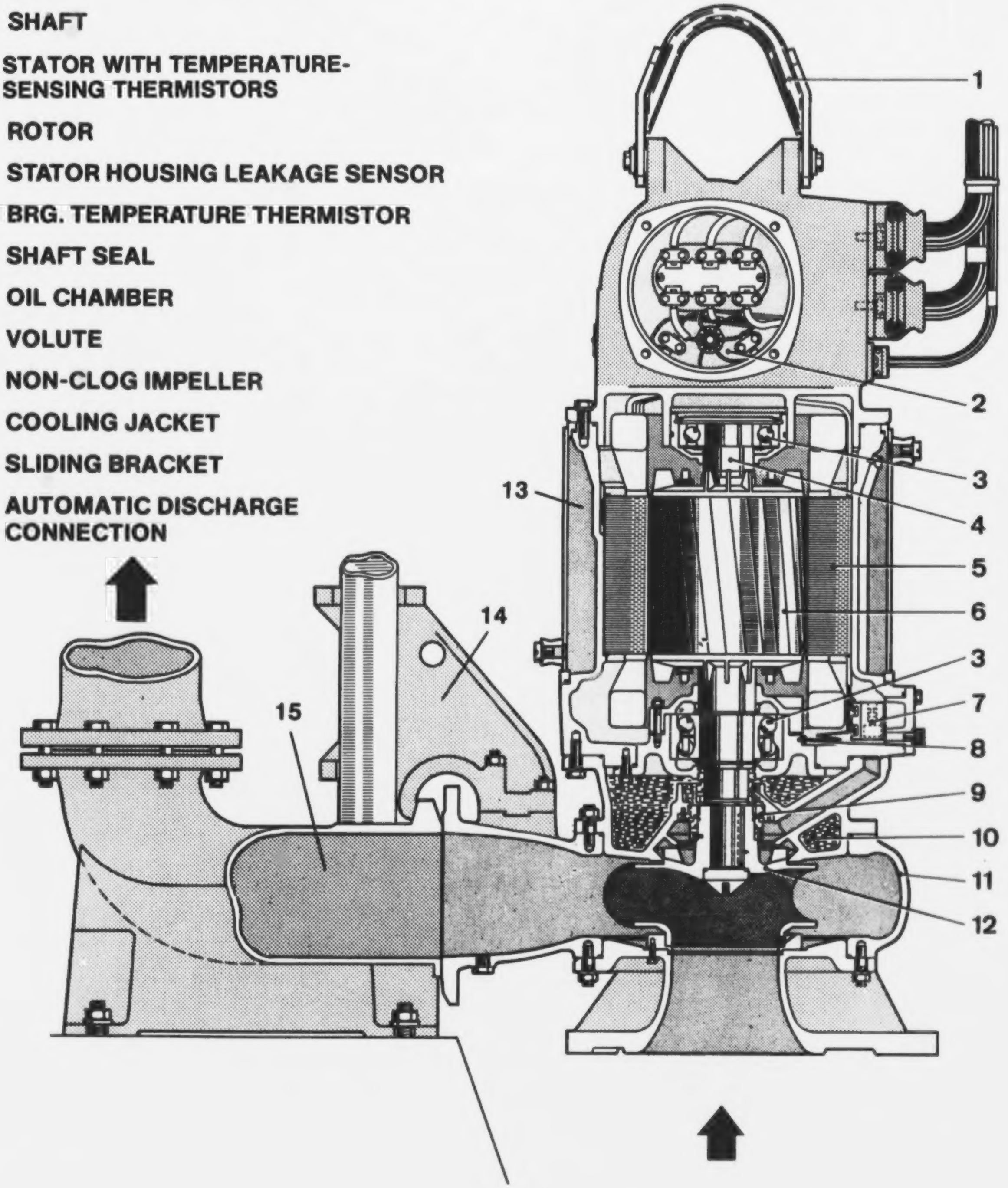


Fig. 9.24 Submersible wastewater pump

(Courtesy of Flygt Corporation)

9.427 Centrifugal Trash Pumps

Centrifugal pumps designed for use as portable pumps are often referred to as trash pumps because the water being pumped is not clean and may have solids of various sizes suspended in the water. When setting up your pump, always prime the pump with clean water. If the priming water contains soap or detergents, problems can develop if a high suction lift exists.

Always locate the pump as near as possible to the surface of the water being pumped (Fig. 9.25). A high suction lift will dramatically reduce pump discharge volume (Fig. 9.26). A centrifugal pump in good condition can perform satisfactorily with a suction lift or vacuum up to 18 inches of mercury. This corresponds to a possible suction lift of 20 feet. Considerable effort is required to start portable centrifugal pumps with excessive suction lift; however, these pumps can operate with considerable suction lift at decreasing flow rates as the water level drops.

When setting up a portable pump, lay out the suction and **discharge hoses as straight as possible to reduce friction losses through kinks and bends in the hoses. The suction hose has a strainer (Fig. 9.27) attached to the entrance to prevent pulling rocks and debris into the pump to avoid damaging the pump or plugging the hoses or pipes. Placing the end of the suction hose in a coarse rock sump or bucket will prevent material building up on the strainer.**

The most frequent pumping problem is an air leak in the suction hose or a connection on the suction side of the pump. To test that the problem is not in the pump, prime the pump, start the engine or motor, and place your hand over the suction inlet. The vacuum created by the pump should draw on your palm with a strong force if there are no leaks. You can also cap the suction inlet and install a vacuum gage on the suction side of the pump to indicate pump operation.

Portable pumps must be protected from being damaged. Whenever a hose must be laid across a roadway, lay a plank on either side of the hose. A vehicle running over the discharge hose while the pump is running may damage the hose and could also cause the pump casing to crack.

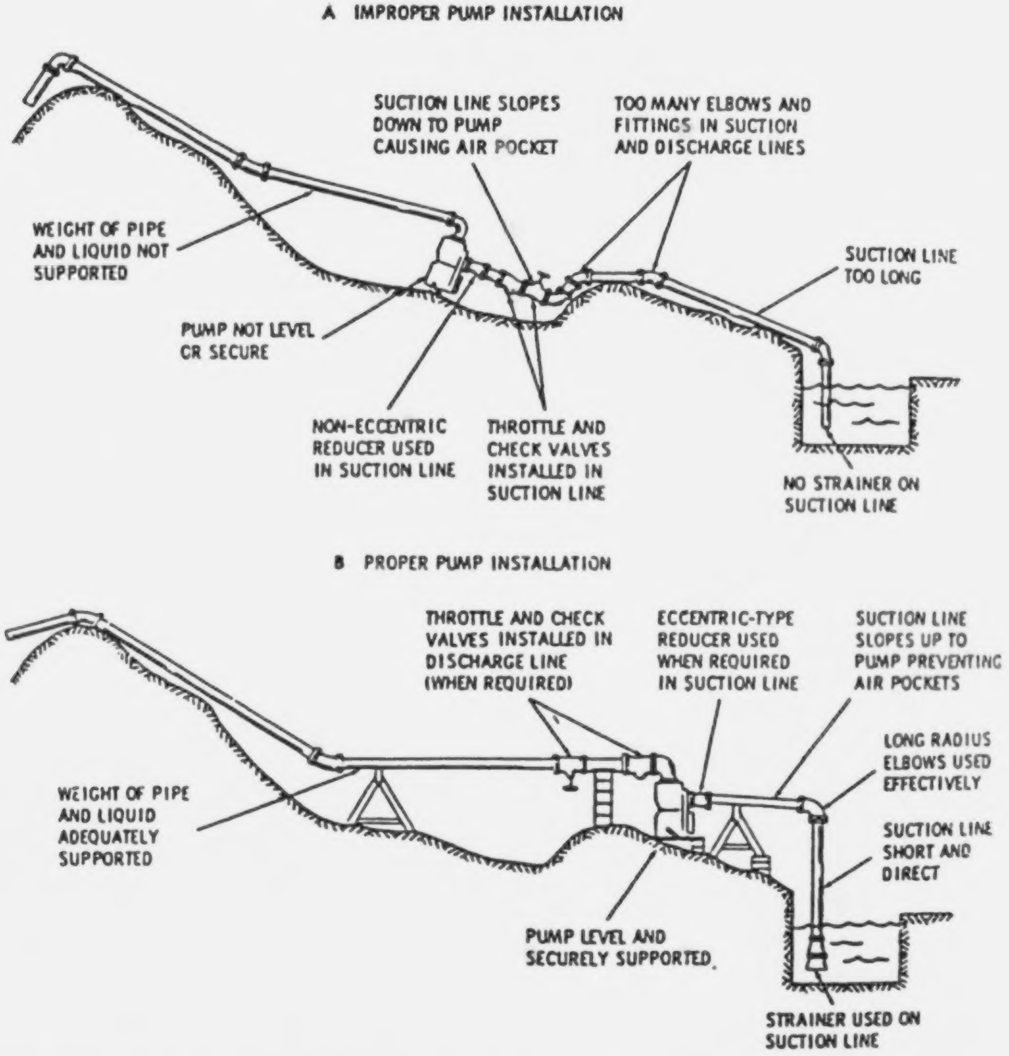

A IMPROPER PUMP INSTALLATION
SUCTION LINE SLOPES DOWN TO PUMP CAUSING AIR POCKET
TOO MANY ELBOWS AND FITTINGS IN SUCTION AND DISCHARGE LINES
WEIGHT OF PIPE AND LIQUID NOT SUPPORTED
SUCTION LINE TOO LONG
PUMP NOT LEVEL OR SECURE
NON-ECCENTRIC REDUCER USED IN SUCTION LINE
THROTTLE AND CHECK VALVES INSTALLED IN SUCTION LINE
NO STRAINER ON SUCTION LINE
B PROPER PUMP INSTALLATION
THROTTLE AND CHECK VALVES INSTALLED IN DISCHARGE LINE (WHEN REQUIRED)
ECCENTRIC-TYPE REDUCER USED WHEN REQUIRED IN SUCTION LINE
SUCTION LINE SLOPES UP TO PUMP PREVENTING AIR POCKETS
LONG RADIUS ELBOWS USED EFFECTIVELY
WEIGHT OF PIPE AND LIQUID ADEQUATELY SUPPORTED
SUCTION LINE SHORT AND DIRECT
PUMP LEVEL AND SECURELY SUPPORTED
STRAINER USED ON SUCTION LINE

Fig. 9.25 Examples of proper and improper portable pump installations

(Permission of the Gorman-Rupp Company, Mansfield, Ohio)

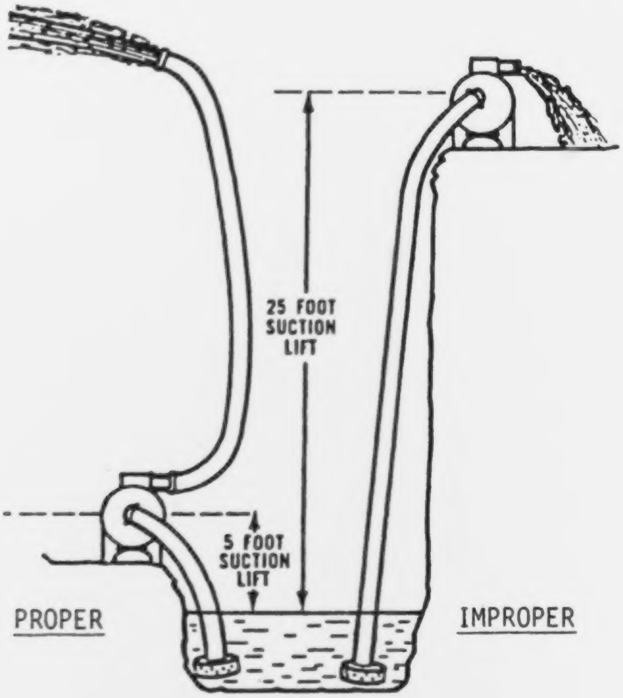

25 FOOT
SUCTION
LIFT
5 FOOT
SUCTION
LIFT
PROPER
IMPROPER

Fig. 9.26 Proper and improper suction lifts
(Permission of Homelite Textron, Charlotte, North Carolina)

PUT THE SUCTION STRAINER ONTO THE END OF THE SUCTION HOSE AND NEVER PUMP WITHOUT IT.

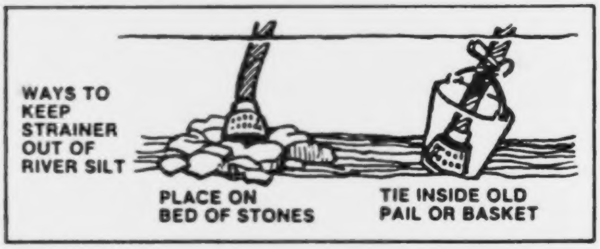

WAYS TO
KEEP
STRAINER
OUT OF
RIVER SILT
PLACE ON
BED OF STONES
TIE INSIDE OLD
PAIL OR BASKET

Fig. 9.27 Proper use of suction strainer
(Permission of Homelite Textron, Charlotte, North Carolina)

If you are operating the pump in weather that is subject to freezing, always drain the pump to prevent the freezing water from cracking the casing or binding up the pump. Before starting the pump, turn the shaft by hand to be sure that it turns freely. If the impeller is frozen fast, warm the pump slowly until the ice melts.

When water containing salt or other corrosives has been pumped, drain the pump bowl and flush with clear water. Also, rinse off the exterior of the pump. By using a slightly oiled cloth or shop towel to wipe off the exterior, you will prevent rusting of the metal. A number of small pumps have cast aluminum casings and are not as resistant to corrosion as pumps having cast iron casings.

Table 9.6 is a portable pump troubleshooting guide which indicates some problems and recommended solutions.

Lubrication should be done in accordance with the pump manufacturer's O&M manual.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 230.

9.42E Why are portable centrifugal pumps often referred to as trash pumps?

9.32F Why should the suction hose of a portable pump have a strainer on the end?

9.42G What precautions would you take when operating a portable pump in weather that is subject to freezing?

9.428 Positive Displacement Diaphragm Pumps

The diaphragm-type pump is a positive displacement pump. A flexible membrane (diaphragm) is used in the vertical cylinder, instead of a piston, and flap valves are used for check valves instead of the common ball checks that are used in the piston type of raw sludge pumps. The concentric movement of the rod alternates the pump from suction to pressure.

Some of the advantages of the diaphragm pump are as follows:

1. Self-priming if the suction lift is small (10 to 15 feet),
2. When primed with water, it will pump with a suction lift up to 25 feet,
3. Large particles will readily pass through the pump (you may have heard of them referred to as "mud hogs" for that reason), and
4. They are less likely to become clogged than centrifugal pumps.

The flow rate is considerably lower with a positive displacement type of pump than with a centrifugal pump. Keeping the pump close to the surface of the water being pumped will ensure maximum output.

To ensure that the pump works satisfactorily, the flap valves must seat properly. Inspect the diaphragm for leaks. If the pump will not prime, inspect the suction hose connections, flap valves, and prime water. Also look for a small hole in the diaphragm that may be causing the problem.

Taking care of the diaphragm pump is similar to the procedures outlined in Section 9.427, "Centrifugal Trash Pumps." However, since some materials used for the membrane tend to deteriorate when exposed to long periods of sunlight, the pump should be stored in a shaded dry area.

To diagnose problems, refer to Table 9.6, Portable Pump Troubleshooting Guide.

9.429 Positive Displacement Diaphragm (Pneumatic) Pumps (Figs. 9.28 and 9.29)

Pneumatically operated diaphragm pumps can be of either the submersible or nonsubmersible type. The theory of operation in either case is quite similar.

Some of the advantages of air-powered diaphragm pumps are as follows:

1. They are resistant to wear,
2. Pumping rate may be adjusted by regulating inlet air,
3. Pump is able to run dry without damage,
4. Discharge line can be closed while pump is operating without damage,
5. Pump performance is more consistent due to less wear,
6. They are self-priming up to approximately 15 feet of suction lift,
7. Some models can be submerged which results in no electrical power near the water, and
8. If you have compressed air in the plant, there is no need to purchase an additional power source.

OPERATION

There are two flexible membranes connected to a common shaft that moves simultaneously in a parallel path. The diaphragm movement is powered by compressed air directed behind one diaphragm while air is exhausted from behind the other diaphragm. When the shaft reaches its length of travel, an air valve transfers the air flow to the diaphragm in the other chamber. Air in the first chamber is then exhausted. This reciprocating action alternately creates suction and discharge of water in each chamber.

The suction and discharge valves (flap or ball type) control the flow of water in their respective cycle of operation. This form of piston-type action is similar to the piston-type positive displacement pump and the diaphragm pump.

MAINTENANCE

The pump should be flushed thoroughly after use to prevent dried sediment from obstructing valve operation. If the water pumped had large particles in it, it may be necessary to dismantle the pump to remove any remaining particles.

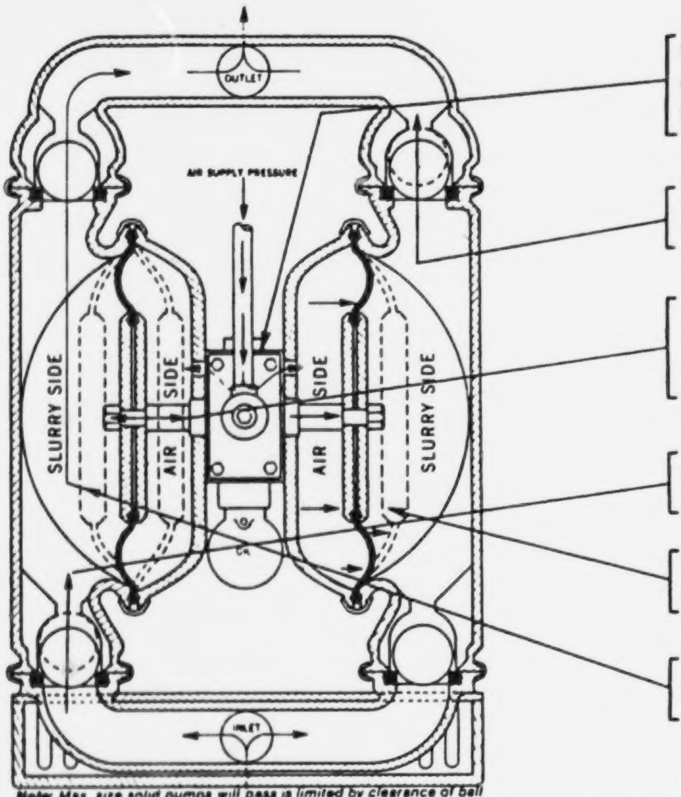
TROUBLESHOOTING

If pump will not cycle, check for:

1. Adequate air pressure,
2. Blocked discharge line,
3. Sliding air distribution valve rod hanging up,
4. Excessive air leak,
5. Plugged exhaust port,
6. Ruptured diaphragm, and
7. Open inlet valve.

TABLE 9.6 PORTABLE PUMP TROUBLESHOOTING GUIDE

PROBLEM	POSSIBLE CAUSE	OPERATOR RESPONSE
1. Pump engine won't start		Follow instructions in manufacturer's engine manual.
2. Pump won't prime		Test pump suction to determine if problem is inside or outside pump.
	INSIDE PUMP	
	a. Pump needs water	Fill with clean water.
	b. Water inside pump contaminated	Drain pump and fill with clean water. Even though pump can pump dirty water, clean water may be needed for priming.
	c. Worn pump	If possible, reduce the suction lift distance. If pump cannot prime at low lift, it should be disassembled and overhauled.
	d. Diaphragm pump valves inoperative, or pump diaphragm leaking	Clean valves or replace leaking diaphragm.
	OUTSIDE PUMP	
	a. Leaking hose or connections on suction side of pump	Make couplings tighter.
	b. Strainer clogged	Clean strainer. Try another method of keeping strainer from clogging.
	c. System clogged	Clean hoses. If necessary disassemble and clean out pump.
3. Flow is scanty	Pump OK, but too small for job	Install larger pump fitted with larger diameter hoses. If a little faster flow would be acceptable, try larger hoses with the same pump.
	Total head including friction is too great	Do everything possible to decrease the head. Try to eliminate unneeded elbows, adapters, and reducers. If possible, move pump closer to the water and shorten hoses.
	Pump leaking or worn	Overhaul pump. Have worn seals, gaskets. impeller, or housing parts replaced as necessary; or shim to reduce clearance between impeller and the wear plate or the housing.
4. Volume decreases during pumping	Roots and other debris keeping diaphragm pump valves stuck open	Elevate discharge hose so water rises to help seal valves. Keep pumping until opportunity arises to stop and clean pump.
5. Pump is "frozen" and won't move	Ice inside pump	Thaw out by gradually warming pump.
	Hard object jammed between impeller and housing	Disassemble pump and remove blockage.
6. Diaphragm pump suddenly stops; engine either quits or keeps running and pump rod slips on shaft	Solid object preventing pump rod from completing stroke	Remove discharge valve and clean cavity.
	Accumulation of grit in housing	Remove grit.


OUTLET
AIR SUPPLY PRESSURE
SLURRY SIDE
AIR SIDE
AIR SIDE
SLURRY SIDE
INLET

Patented, one moving piece air valve directs air supply pressure to back side of diaphragm

Slurry is pushed out of liquid chamber, thru pump outlet

At the same time opposite diaphragm is pulled in by rod connected to pressurized diaphragm

Suction created draws slurry into liquid chamber thru pump inlet

When pressurized diaphragm reaches limit of stroke, air valve shifts air supply pressure to back side of diaphragm which was pulled in. Slurry is pushed out of liquid chamber thru pump outlet.

On discharge stroke, pressure on both sides of diaphragm is equal & discharge pressure is equal to air supply pressure.

Note: Max. size solid pumps will pass is limited by clearance of ball check valve off valve seat M-4·3/16," M-8·1/4," M-15·3/8"

Fig. 9.28 Diaphragm (pneumatic pump)

(Permission of Wilden Pump & Engineering Co., Colton, California)

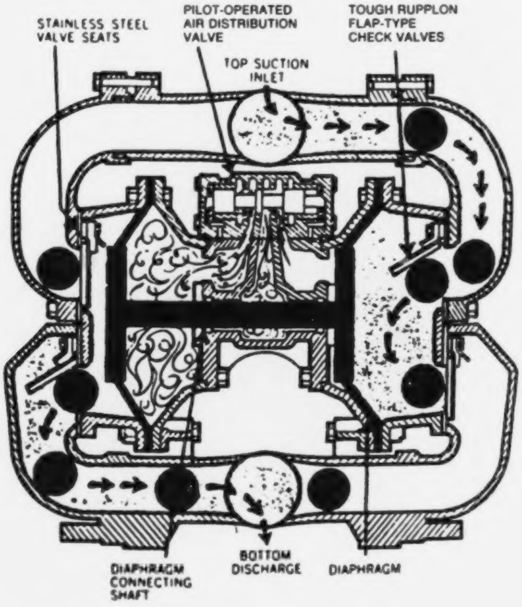

STAINLESS STEEL VALVE SEATS
PILOT-OPERATED AIR DISTRIBUTION VALVE
TOUGH RUPPLON FLAP-TYPE CHECK VALVES
TOP SUCTION INLET
DIAPHRAGM CONNECTING SHAFT
BOTTOM DISCHARGE
DIAPHRAGM

Fig. 9.29 Diaphragm (pneumatic) pump

(Permission of Warren Rupp Company, Mansfield, Ohio)

If pump cycles but will not pump, check to see if:

1. Suction side of pump is pulling in air,
2. Suction line is plugged,
3. Check valves (ball or flap) are not seating, and
4. Suction lift is too high.

If output flow rate is low, determine if:

1. Air pressure to pump is low,
2. Suction is restricted and accompanied by fast cycling of pump,
3. Discharge is restricted with slow cycling of pump, and
4. Valve seating is improper.

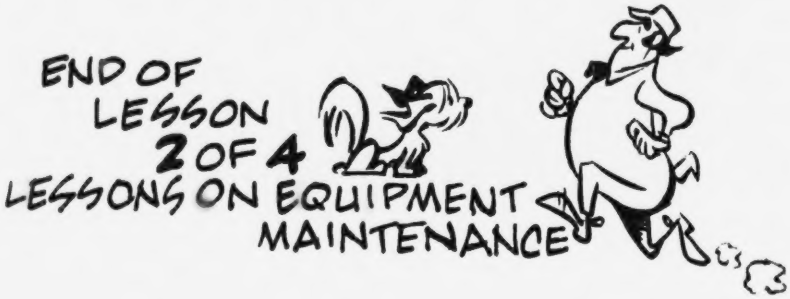
QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 230.

9.42H List the advantages of a positive displacement diaphragm pump.

9.42I What would you do if a diaphragm pump suddenly stops pumping and the engine either quits or keeps running and the pump rod slips on the shaft?

9.42J What maintenance should be performed on a pneumatically operated diaphragm pump after use?



DISCUSSION AND REVIEW QUESTIONS

Chapter 9. EQUIPMENT MAINTENANCE

(Lesson 2 of 4 Lessons)

Write the answers to these questions in your notebook before continuing. The problem numbering continues from Lesson 1.

7. What types of water and material can be pumped by a pump?
8. Why is proper maintenance of a pump important?
9. Why must a pump be in proper alignment?
10. What are the uses of the different types of pumps?
11. Under what conditions would you recommend the installation of a screw pump?
12. What are the advantages of a pneumatic ejector?

CHAPTER 9. EQUIPMENT MAINTENANCE

(Lesson 3 of 4 Lessons)

9.5 PUMP COMPONENTS

9.51 Impellers

The heart of a centrifugal pump is the impeller. As stated earlier, this is the device where spinning causes a centrifugal force that pumps the wastewater. There are many different types of impellers, such as propeller, turbine, mixed flow, and radial. These impellers may be open, closed, or semi-closed. Photographs of different types of impellers are shown in Figures 9.30 and 9.31.

The most common impellers used in wastewater centrifugal pumps are semi-closed or closed-type radial for larger pumps and open impellers for smaller sludge pumps. These are used because they will pass solids with less chance of plugging. These impellers require a specific clearance between the pump volute. Generally, for wastewater these clearances are set at .010 to .012 inches. Freshwater pump clearances are approximately .002 to .005 inches. The reason for larger clearances in wastewater pumps is to retard erosion by solid particles such as grit and sand.

Pump impellers should be inspected for wear on a regular basis such as every 6 months or annually, depending on pumping conditions. Before inspecting a pump impeller you should:

1. Turn off and lock out all electrical power to pump ("Main Circuit Breaker" and "Start-Stop Station" — don't lose a finger or arm),
2. Tag control panel with a "Do Not Start" tag stating time, date, and your name or initials,
3. Close suction and discharge valves (do not depend on discharge check valve), and
4. Drain pump with bolts still in handhole cover until water stops (many a lift station has been flooded because something prevented a valve from closing). If bottom of volute has a drain, use it.
5. Open handhole covers and visually inspect for foreign objects which will injure you (razor blades, sharp objects, needles in rags). Turn the shaft by hand and listen for loose objects. Inspect for binding by rags, rope or metal. Use a special hook or tool to remove trash, but not your hands. When the area is clear, the insides can be inspected.

When inspecting a pump impeller you should look for the following items.

1. Cavitation marks. They appear as holes, indentations, bullet chips, and cracks.
2. Chips, broken tips, corrosion, unusual wear.
3. Tightness on shaft. Hold shaft and try to wiggle impeller, inspect impeller nut. Pry with wood up and down.
4. Clearances. This is done by inserting a feeler gage between pump volute or faceplate and impeller if the pump does not have wearing rings. With wearing rings, clearance is adjusted between wearing rings on the impeller and volute faceplate.
5. Excessive wear on wearing rings on impeller and volute.
6. If impeller is rubber coated, look for tears or bubbles in coating.

If any of the above problems are noticed, your supervisor should be notified and it should be noted in the equipment file for that pump.

Excessive clearances can cause frequent plugging and loss of pump capacity. As pumps wear or clearances become excessive, pump efficiency is lost and the motor will draw fewer amps. However, total power usage will increase because the pumps will have to operate longer to pump the total flow. Many pumps have impellers which can be adjusted fairly easily. One method is removing shims from the upper bearing housing or between the upper bearing and shaft. Another method used is a threaded bearing assembly which can be loosened and screwed up and down. Still another method is shimming impeller or faceplate. You will have to consult your pump manual for the particular method to be used on your pump.

Many wastewater pumps are fitted with wearing rings on the impeller and volute, or faceplate. These wearing rings are installed so they take the wear rather than the impeller or volute and are replaceable. In other words, they protect the impeller and pump casing from damage due to excessive wear by solids and grit. These wearing rings are made of materials such as bronze, stainless steel, and Teflon. They are fabricated and installed so that they can be replaced when worn, thus not having to replace the entire impeller or volute. Wearing rings are usually pressed or pinned on the impeller and volute. Sometimes they are threaded with a set screw holding them. The pump manufacturer's literature will inform you what type is installed in your particular pump. Wearing rings must be replaced when worn excessively or when clearances between impeller and volute cannot be attained. Be sure to replace them before they become worn through or wear starts on volute or impeller, because new wearing rings will not fit properly on worn down volutes or impellers.

In order to replace wearing rings it is necessary to dismantle the pump head from the volute. The worn rings are removed by chiseling, cutting, or grinding off. When the impeller is removed, a new wearing ring can usually be pressed on under a press. Another method is to heat the wearing ring in hot oil and tap over impeller with a block of hard wood after it has expanded. Make sure the wearing ring is installed completely and do not scarf or burr a new ring with metal punches or drift pins. If burred, file off before installing in volute.

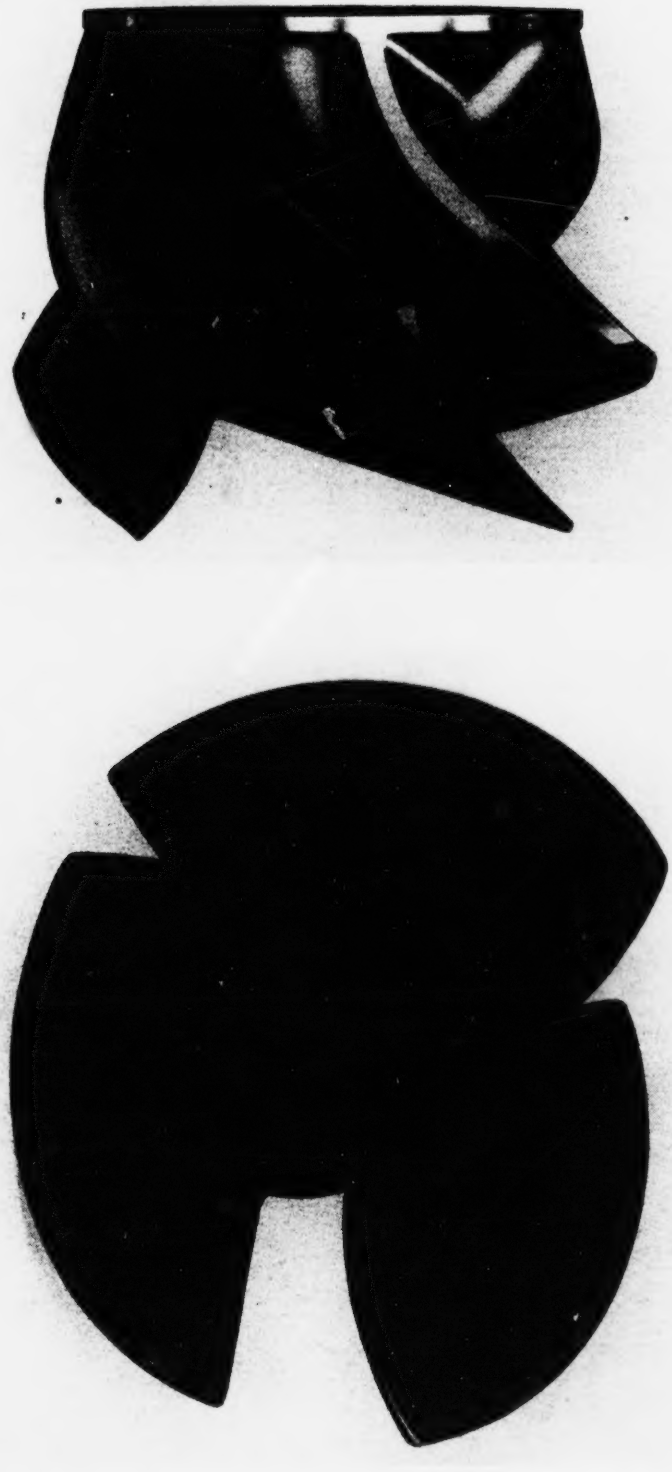


Fig. 9.30 Impellers

(Source: Centrifugal Pumps by Karassik and Carter of Worthington Corporation)

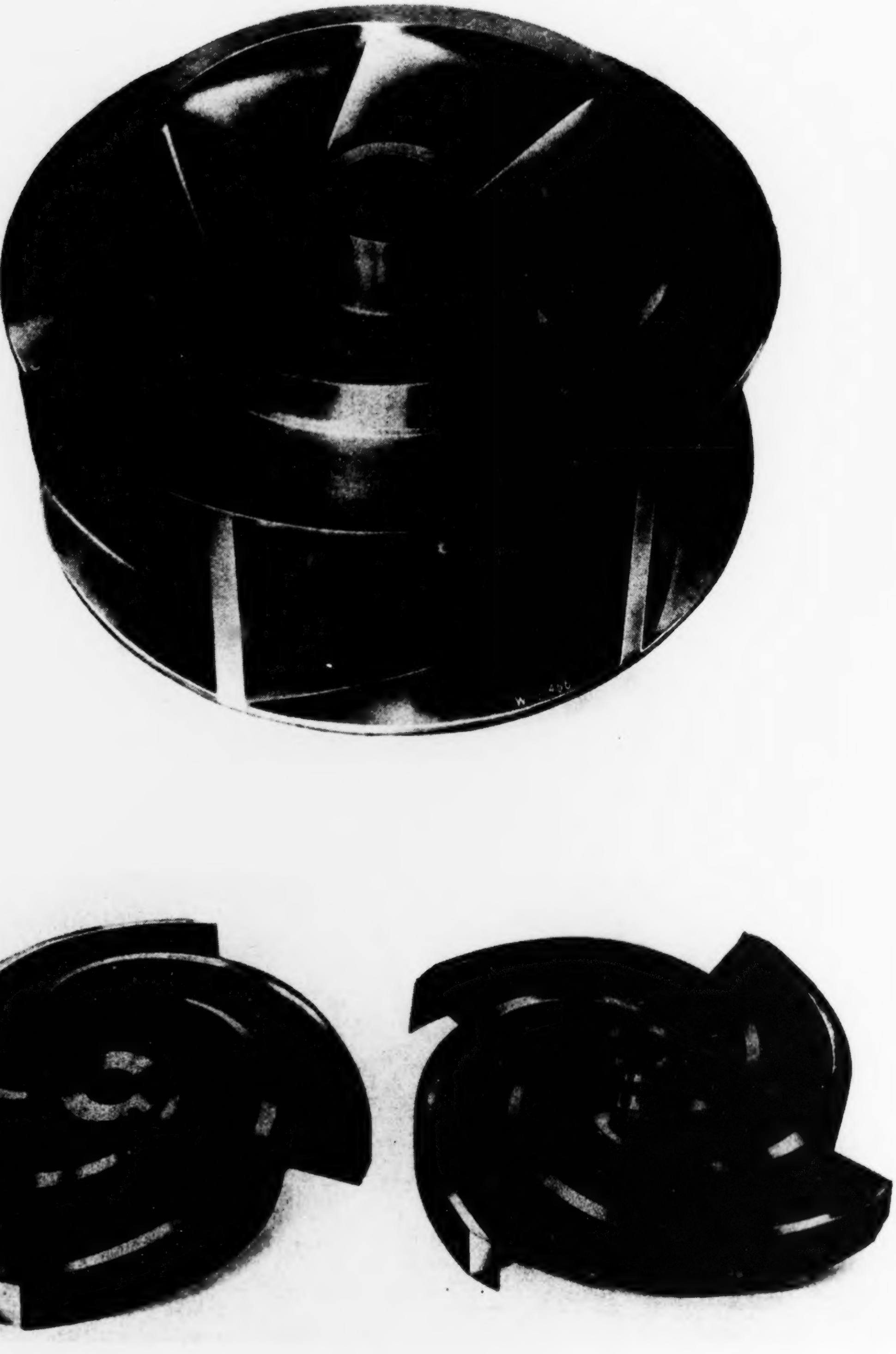


Fig. 9.31 Impellers

Source: Centrifugal pumps by Karassik and Carter of Worthington Corporation)

The volute wearing ring can sometimes be installed by pressing or tapping. It is much easier to freeze the wearing ring with dry ice, shrinking it, and dropping or tapping it into place with wood or plastic drift. Before installing either wearing ring, make sure mating surfaces are clean and free of nicks and burrs. Also be sure the wearing rings are properly seated into the intended position.

The replacement of wearing rings is generally done by qualified mechanics and special tools are required. Since the pump has to be removed and dismantled, special tools are required such as hoists, presses, chains and slings, punches, chisels, wrenches, and power tools. Care must be used to prevent damage to pump or parts being repaired.

Cavitation is caused by the pump operating at conditions different from those for which it was designed, such as operating off design curve, poor suction conditions, high speed, air leaks into suction end, and water hammer conditions. Many of these are not controlled by the maintenance operators, but some items can be checked.

1. Make sure suction valve is all the way open. Never throttle a suction valve.
2. Examine wet well level and insure pump is not sucking in air or pumping too low before shutting off. Also look and be sure pump is not picking up air by vortexing (whirlpools) at inlet of suction line.
3. Inspect suction line to make sure it is not partially plugged with grease or foreign material such as sand, grit and rocks.
4. Inspect bottom of wet well for grit deposits.
5. Examine maximum speed setting on pump to determine if correct.
6. Look for places where air could be leaking in at packing.

Worn, broken, chipped, or damaged impellers can be repaired only by welding, machining, or replacing. This will require the services of a mechanic with expertise in pump repair.

Loose or unbalanced impellers should be repaired by a mechanic immediately and before further damage to the pump occurs. If a pump is left in this condition, the shaft could break and the pump could be damaged beyond repair. Unbalanced impellers may vibrate, fracture and possibly rupture the volute. Impellers must be dynamically balanced after any repair work.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 230.

9.51A How often should impellers be inspected for wear?

9.51B What is the purpose of wearing rings?

9.51C What can happen if clearances are not kept in proper adjustment?

9.51D How can you tell if an impeller has damage from cavitation?

9.51E What causes cavitation?

9.52 Shafts

Pump shafts are used to turn the impeller, mount the bearings, and are connected to a pump driver of some type. These shafts are generally fabricated from an alloy steel machined to size. They are machined to exact tolerances and must be maintained this way for proper operation. There are four major areas to a shaft:

1. Impeller end,
2. Coupling end,
3. Bearing fits, and
4. Stuffing box area.

The impeller end is where the impeller is pressed, keyed, or secured on to the shaft. This part of the shaft is usually not a problem to maintain. If the impeller is kept tight, there should never be a need to repair this shaft area during regular use.

The coupling end is where the coupling mounts on the shaft to connect to the driver, and is usually never in need of repair. When removing or installing a coupling, the coupling end should be cleaned thoroughly and lubricated. Rust can sometimes be a problem and must be removed.

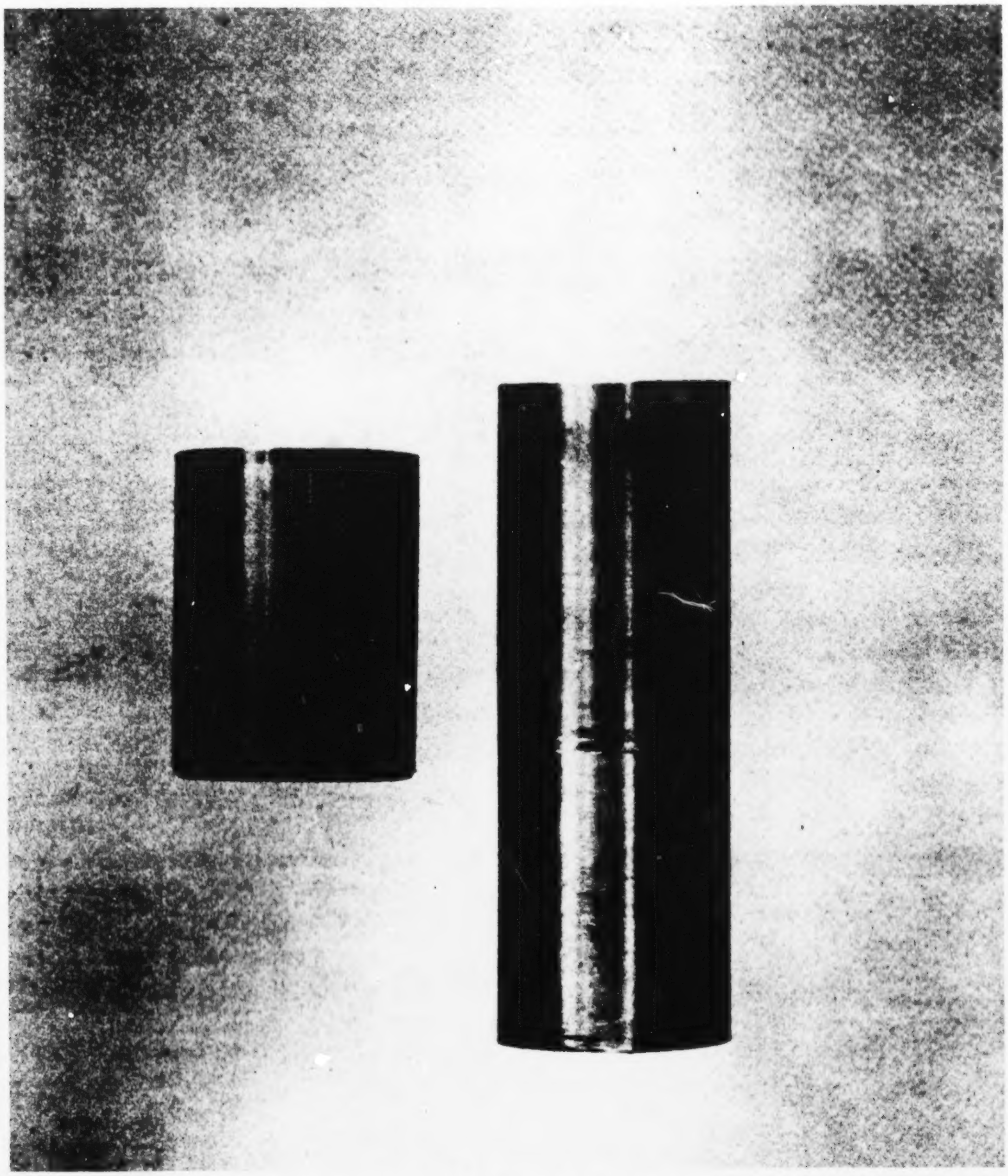
Bearing fits or journals are where the bearings are installed on the shaft. These are designed to have press fit tolerances as specified by the pump manufacturers. They are not usually a maintenance problem unless a pump with a bearing which has failed is left running for an extended time. If this happens, the inner race of the bearing could turn or spin, thus damaging the bearing fit. If this happens, it will be necessary to remove the shaft and have it metal sprayed and ground down to size by a machine shop. The machine shop will need to know the bearing number so they can machine the shaft to proper size. Bearings are discussed in Section 9.37, Bearings.

The most important problem section with a pump shaft is the stuffing box area. The pump packing, if not properly cared for, will cut grooves into the shaft in this area. Some of the reasons for grooves being cut into the shaft are:

1. Packing glazed when pump was started,
2. Worn packing that allows leakage from the volute when pump is operating (this leakage can carry grit or other foreign solids into the stuffing box),
3. Dirty seal flushing water,
4. Water seal pressure set too low or plugged,
5. Wrong type packing,
6. Shaft sleeve (seal cage) slipping, and
7. Improper packing adjustment, such as packing too tight.

Two very acute problems arise when this happens. The first thing is that once the shaft is scored or grooved, packing will not last. The grooves will rip and tear out new packing in a very short time. The second problem is the shaft is weakened and, if left, will be damaged beyond repair.

Manufacturers have realized the wear problem with the shaft in the stuffing box area and designed shaft sleeves (Fig. 9.32) to avoid this problem. Shaft sleeves are installed over the shaft in the area on the shaft where it passes through the stuffing box. These sleeves are usually made of stainless steel, chrome or ceramic-plated alloy steel, bronze, or other materials suitable for the pumping application. The shaft sleeve is either keyed on, pressed on, threaded on, or held by the impeller. Shaft sleeves are designed to protect the shaft by taking the wear from the packing. To replace a complete shaft is very costly compared to a shaft sleeve. Shafts and/or shaft



NOTE: Also see Figure 9.18 and Figure 9.19 for location of shaft sleeve on pump shaft inside of stuffing box.

Fig. 9.32 Pump shaft sleeves
(Courtesy Worthington Corporation)

sleeves should be inspected every time the pump is repacked. This inspection has to be done when the pump packing is removed and stuffing box cleaned out. In order to see the shaft sleeve it might be necessary to use a small mirror, such as a dental mirror, and flashlight. Inspect for grooves, split shaft seal and any other unusual conditions. The sleeve should be repaired or replaced when grooves are observed. It must be replaced before wearing through to the shaft. To replace the shaft sleeve, it is necessary to remove and dismantle the pump. Usually, just the impeller needs to be removed and the sleeve can be pulled off.

Some shaft sleeves are extremely difficult to remove and they can be damaged so repair is impossible. Try heating the sleeve and/or freezing the shaft to break bond and increase clearance. Shafts and shaft sleeves can be repaired by metal spray, ceramic spray, or chrome plating. This method may cause problems because, if not properly done, it will cause distortion. If a sleeve is worn, it should be replaced.

Replacing a shaft or shaft sleeve requires specialized tools and competent operators with a thorough knowledge of pumps and mechanics. The maintenance operator usually does not replace a shaft or shaft sleeve.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 230.

9.52A How can pump shafts be protected from damage?

9.52B When should a pump shaft sleeve be repaired or replaced?

9.53 Packing (Fig. 9.33)

Packing is probably the single biggest problem for the maintenance operator maintaining pumps. More pumps have been damaged due to improper maintenance of packing than any other reason. If packing is not maintained properly the following troubles can arise:

1. Loss of suction due to air being allowed to enter pump,
2. Shaft or shaft sleeve damage,
3. Water or wastewater contaminating bearings,
4. Flooding of pump station, and
5. Rust corrosion and unsightliness of pump and area.

Packing is used to provide a seal where the shaft passes through the pump casing in order to keep air from being sucked into the pump and/or the water being pumped from coming out.

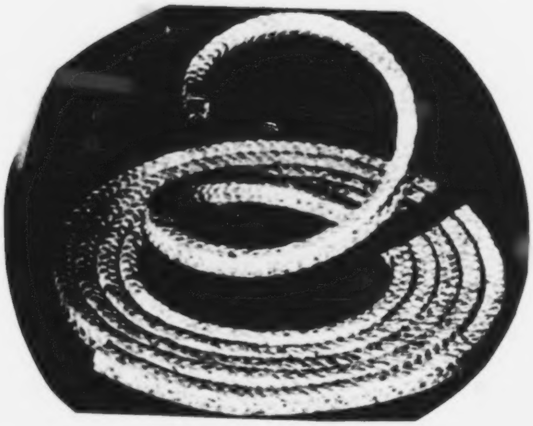
There are probably over 500 different types, grades, manufacturers, and styles of packing on the market today. Packing can be round, square, loose, pointed, or almost any size, shape or form. It is manufactured from jute, hemp, Teflon, asbestos, rubber, lead, and many other materials too numerous to mention. The pump manufacturer should recommend the proper packing on the basis of the following:

1. Type of pump and manufacturer's recommendation,
2. Material being pumped (water - wastewater - acid - alkali - scum - sludge - grit - and others),
3. Temperature of liquid being pumped,
4. Grease or water flushing, and
5. Peripheral (outside) speed of shaft.

Do not pick a cheap grade of packing due to price because it will cost you more in the end when shaft sleeves are damaged or time required to repack. Generally, in wastewater pumps, braided asbestos material is used; it can be graphite impregnated, Teflon coated, or of a similar material.

Let's start our packing procedure by placing a new wastewater centrifugal pump into service. The first consideration is to determine if the packing installed at the factory is still good. Since it arrived on the job site in February and wasn't installed until August, we must assume that it has been sitting for at least seven months in the weather. The contractor had some plastic over it, but it finally blew off. The packing has been rained on, the wind blew dust over it, and now it's 101°F outside so it's baked. If not, to make matters worse, you notice that the painter has helped by coating the pump (name plate included) with one coat of primer and two coats of enamel. Okay, let's repack the pump before we start it and not ruin the shaft sleeve. Also we better make sure the shaft and the rest of the pump are ready to go after sitting outdoors before we start the pump. Get the manufacturer's literature and study it.

1. Turn off the main circuit breaker for this pump and control switch.
2. Lock it in the OFF position and tag it OFF (fill out a card with date and initials).
3. Close suction and discharge valves.



Teflon Packing

Graphite Packing

Fig. 9.33 Packing
(Courtesy A.W. Chesterton Co.)

4. Drain pump by loosening bolts on handhole cover. *DO NOT REMOVE BOLTS COMPLETELY UNTIL PUMP STOPS DRAINING AND YOU ARE SURE THAT THE SHUT-OFF VALVES ARE HOLDING.* If available, drain pump by using drain valve or plug at bottom of volute.

5. Remove packing gland nuts and/or bolts and remove glands. These are usually split for removal. If the packing gland is not split for removal, it has to be backed off on the shaft. Provide room for removal and replacement of packing.

6. Remove packing. The packing rings can be removed by screwing a packing hook (Fig. 9.34) into them and pulling out. Sometimes it helps to revolve the shaft while pulling. *CARE MUST BE TAKEN WHILE USING THE PACKING HOOK THAT THE SHAFT ISN'T SCORED OR NICKED.*

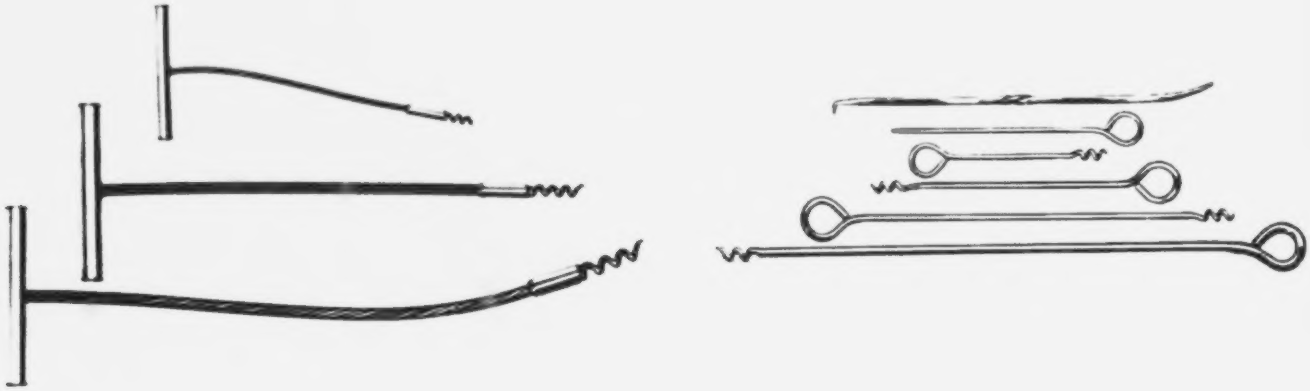


Fig. 9.34 Packing hooks

(Courtesy A.W. Chesterton Co.)

7. After you have removed the top rings of packing, the lantern ring (seal cage) must be removed. This can usually be fished out with a heavy piece of wire, coat hanger, or welding rod. Some have a threaded hole in which a ¼-inch bolt can be inserted. If the pump has been in service for a while, you will have to clean around the shaft and stuffing box to get it out. Try tapping with a wooden dowel to loosen it up if you are still having trouble removing it. Another approach is to turn the pump on and blow the ring out with pump pressure — messy, but effective. Always remove the ring. These also are usually split so they can be removed from the shaft.

8. Next, remove the remaining packing rings according to the manufacturer's drawing. They are usually more difficult to remove after a pump has been in service.

9. Wash all parts with soap and water and scrub with a wire brush, if necessary. *THOROUGHLY CLEAN INSIDE THE STUFFING BOX AND THE SHAFT.* Wipe parts dry.

10. Disconnect seal water line or spring grease cup. Clean thoroughly and inspect its operation.

11. Make sure that seal water hole through stuffing box is clear and clean.

12. Inspect shaft or shaft sleeve for wear and cleanliness. Make sure that the lantern ring was positioned properly and the manufacturer's print was correct. If the number of rings of packing to be installed before the lantern ring is unknown, insert enough packing so that the lantern ring is correctly positioned with the seal water or grease inlet when the packing has been pushed into the recess as far as it will go. Each packing ring should be cut to fit the shaft.

13. Determining packing requirement.

    A. Determine packing size. Measure from outside of shaft to inside of stuffing box with a scale. Whatever the measurement is, this is the size of the packing. Let's assume this is ½ inch; therefore, ½-inch square packing is used.

    B. Measure the depth of the stuffing box, outside face to inside bottom. Let's assume this measurement is 4 inches.

    C. Measure from bottom of stuffing box to center of seal water inlet. Let's assume this is 1¾ inches.

    D. Measure lantern ring or seal cage, and again, let's assume this is ½ inch.

    E. With a 4-inch depth and subtracting the ½-inch seal cage, we have 3½ inches that can be filled with packing. 3½ inches divided by ½ inch (size of packing) allows us 7 rings of packing to be inserted.

    F. The seal cage should be located in the stuffing box so that it is centered where the seal water or grease enter. Take the seal cage measurement and divide it in half. ½ inch divided by 2 equals ¼ inch. The measurement from the bottom of stuffing box to center line of seal water inlet was 1¾ inches. By adding 3 rings of ½-inch packing (which equals 1½ inches) and adding the ¼ inch for seal cage, we arrive at 1¾ inches, which puts the seal cage at the seal water inlet.

As stated earlier, this information usually can be taken from the manufacturer's literature.

Now that we know the size of packing, number of rings needed, and where to position the seal cage (lantern ring), we can start repacking the pump.

Packing should be kept in a clean place. Never allow the protective wrapping to be left off or the box uncovered. Do not allow packing to come in contact with solvents or high temperatures which could force lubricant out of it. Discard any packing that has become contaminated with dirt, sand, grit, or other foreign material.

14. Packing the pump.
    A. Cut packing to proper length using a very sharp knife, and on a clean board.
        1) If proper length is not known, wrap around a mandrel of the same size as the shaft, or wrap around the shaft itself, and cut.
        2) Make clean cuts, no ragged edges.
        3) If possible, cut packing on shaft so parallel ends can be obtained.
        4) Cut all necessary rings at one time.
    B. Roll packing flat with short pipe on a clean bench, or tap slightly so it will fit into the stuffing box more readily.
    C. Wrap the new packing rings (*ONE AT A TIME*) around the shaft and insert into the stuffing box, keeping joints together. Tap into place with gland or a split wooden bushing.
    D. Stagger the joint or butts of the packing around the shaft. For example:
        1) First ring — place butt or joint on right side of shaft.
        2) Second ring — place butt or joint on left or opposite side of shaft.
        3) Third ring — place butt at top of shaft.
        4) Fourth ring — place butt at bottom of shaft.
        5) Repeat procedure for more rings.
    E. Position the lantern ring (seal cage) so it is centered in the seal flush opening. Remember the ring moves back deeper into the box as packing is tightened.
    F. Install the three packing rings. Stagger the joints in the same sequence as the first three rings.
    G. Install packing gland keeping the gland square at all times.
        1) The last ring of packing may have to be left out and installed after the packing is seated.
        2) Tighten packing gland just enough (hand tight) to prevent excessive leakage before starting the pump.

To start a new or repacked pump, use the procedures listed below.

1. The first thing to do is to make a visual inspection. Look for loose nuts and bolts, guards left off, tools left around, and any other unusual condition.
2. Open suction and discharge valves. Make sure they are completely open.
3. Turn on seal water or make sure grease cups are full.
    a. Seal water can be either fresh water from an air gap system or recycled, filtered water.
    b. Seal water pressure should be adjusted to 5 psi higher than the maximum pump discharge pressure.
4. Prime pump by venting air or filling pump case with water from a hose or a bucket.
5. Remove electrical lock out tag and unlock main circuit breaker.
6. Start pump and observe its operation.
    a. Inspect gages to see if pumping.
    b. Listen for any unusual noises.
7. Adjust packing gland.

    Probably more packing jobs are ruined by improper gland adjustment than for any other single reason.

    a. Tighten the packing gland just enough to prevent excessive leakage.
    b. As the packing adjusts itself to the shaft, tighten the gland slowly one half turn at a time on each nut, keeping gland square until the leakage is reduced to the desired number of drops per minute.
        1) Leakage of 20 to 60 drops per minute is desired.
        2) Pumps with grease lubrication should not leak, but do not overtighten.
        3) Keep packing gland square with pump shaft to prevent rubbing on shaft. To keep gland square, hand tighten first bolt until slack is taken up. Insert other packing gland bolts and tighten to point of first resistance. Next tighten each bolt one flat at a time on alternate sides to insure an even take up until the leak rate is properly adjusted. Uneven take up jams the packing and the shaft.

Usually the gland is not pulled up more than finger tight to maintain the proper leakage. If the gland becomes too hot to touch, it is pulled up too tight.

Stop the pump and allow the packing to cool, then readjust it. Do not back off on gland while pump is running because entire set of packing will move out, not relieving any pressure on the shaft. Start the pump and determine gland temperature. It may be necessary to start and stop the pump several times before desired leakage and temperature are obtained. Small motors may be stopped and started several times in a short period, but severe motor damage can occur in large motors when there are excessive starts and stops within a given period. Inspect seal water again and make sure it is entering packing. Clean filters and strainer as necessary to maintain flushing water supply to packing gland. If one ring of packing was left out, be sure and install it when packing is sealed. Below are some causes of shaft packing failures provided courtesy of A.W. Chesterton Company.

A used or worn set of packing can be of value as it often indicates cause of premature packing failure. Examine worn packing carefully. The following tabulation should be helpful in tracking down packing troubles.

INDICATION	SUGGESTIONS
No leakage at start up.	Back off gland to encourage generous leakage. If negative suction, install lantern and connect to discharge.
Excessive leakage at start up.	Check for correct packing size. Were rings installed correctly in accordance with instructions. Check pump for run-out.
Packing rings flattened out on I.D. under the rod or shaft.	Check bearings. Packing probably supporting the shaft weight.
Packing rings flattened out above rod or shaft, or on either side of same.	Check alignment of shaft. Worn bearings may be causing whip or run-out.
Distinct bulge on side of ring.	Probably too wide a gap on adjacent ring — rings cut too short
Sides of rings shiny or worn.	Rings may be too loose and are rotating with the shaft.
Rings extruding past gland follower.	Too much clearance between O.D of shaft and I.D. of follower. Apply bushing. May also be excessive gland pressure.
Top or gland end rings in poor condition, bottom rings O.K.	Set improperly installed.
Rings disappear in set.	Packing entering the system. Install bottom bushing.
Packing is torn.	Check sleeve for burrs. Are there any abrasives?
Rings are burned, faces dried and charred.	Check for proper size packing. Is packing the correct selection with respect to heat limitations and/or peripheral speed? Check lubrication. Are there any abrasives?
Packing hardens.	See "burned rings" above. Are there congealing liquids involved?
Packing softens.	Check for proper style selection, also for lubrication.
Excessive loss of lubricant.	Excessive gland pressure. Check for packing selection, temperature, whip in shaft.
Unexplained leakage.	Shaft sleeve may be leaking. Replace sleeve seal under sleeve.
Packing freezes to shaft after shutdown.	Liquid salting out or congealing in packing set. Provide lubrication to packing before shutdown.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 230.

9.53A What is the purpose of packing?

9.54B What is the purpose of the lantern ring?

9.54 Mechanical Seals (Fig. 9.35)

Many pumps use mechanical seals in place of packing. Mechanical seals serve the same purpose as packing; that is, they prevent leakage between the pump casing and shaft. Like packing, they are located in the stuffing box where the shaft goes through the volute; however, they should not leak. Mechanical seals are gaining popularity in the wastewater field.

Mechanical seals have two faces which mate that prevent water from passing through them. One half of the seal is mounted in the pump or gland with an "O" ring or gasket, thus providing sealing between the housing and seal face. This prevents water from going around the seal face and housing. The other half of the mechanical seal is installed on the pump shaft. This part also has an "O" ring or gasket between the shaft and seal to prevent water from leaking between the seal part and shaft. There is a spring located behind one of the seal parts which applies pressure to hold the two faces of the seal together and keeps any water from leaking out. One half of the seal is stationary and the other half is revolving with the shaft.

Materials used in the manufacture of these seal parts are carbon, stainless steel, ceramic, tungsten carbide, brass, and many others. The different type materials are selected for their best application. Some of the variables are:

1. Liquid and solids being pumped,
2. Shaft speed,
3. Temperature,
4. Corrosive resistance, and
5. Abrasives.

Initially, mechanical seals are much more expensive than packing to install in a pump. This cost is gained back in operating costs during a period of time.

Some of the advantages of mechanical seals are as follows:

1. They last from three to four years without having to touch them, resulting in labor savings,
2. Usually there isn't any damage to the shaft sleeve when they need replacing (expensive machine work is not needed),
3. Continual adjusting, cleaning, or repacking is not required, and
4. The possibility of flooding a lift station because a pump has thrown its packing is eliminated; however mechanical seals can fail and flood a lift station too.

Some of the limitations of mechanical seals are as follows:

1. High initial cost,
2. Competent mechanic required for installation,
3. When they fail, pump must be shut down, and
4. Pump must be dismantled to repair.

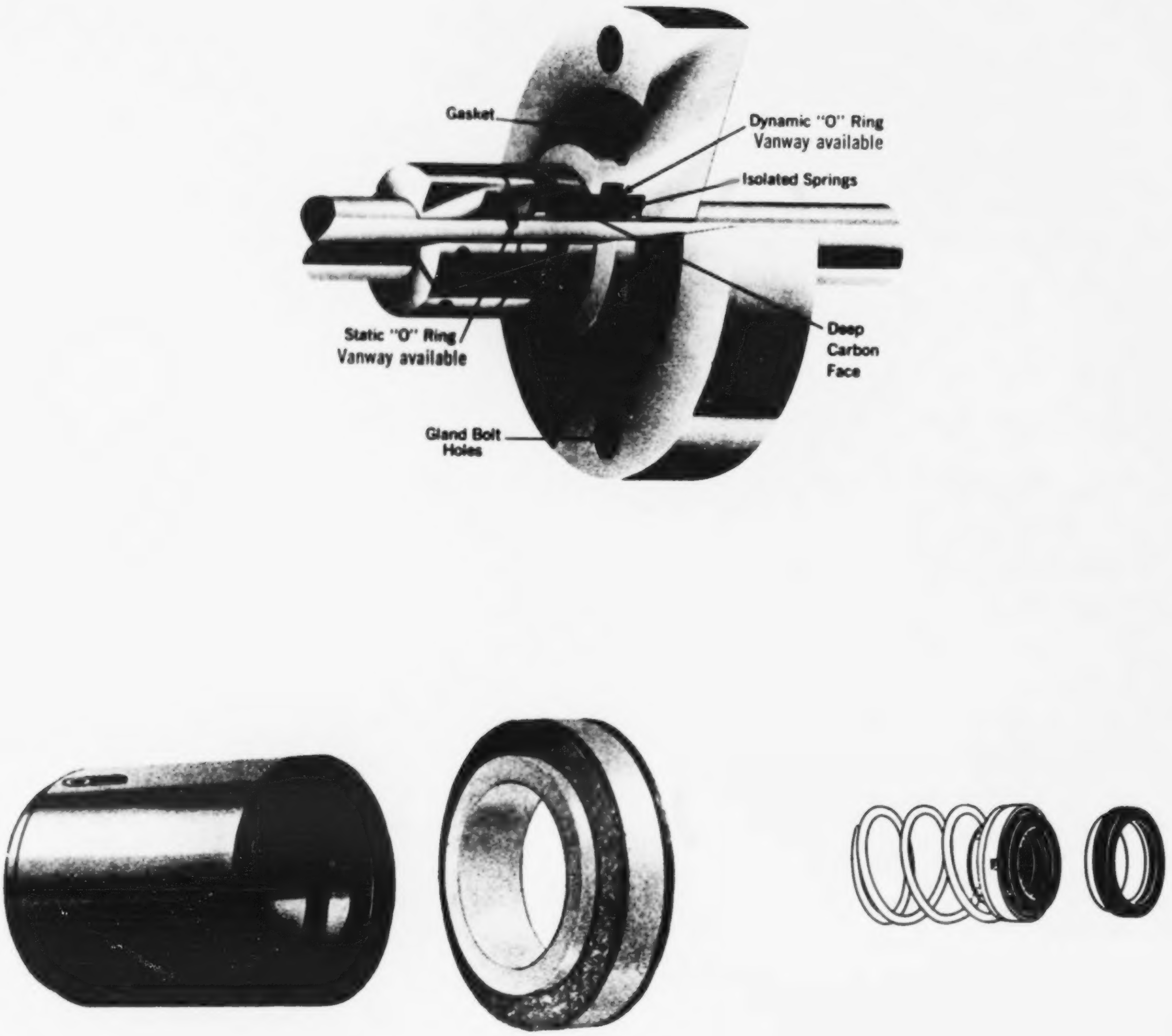

Gasket
Dynamic "O" Ring
Vanway available
Isolated Springs
Static "O" Ring
Vanway available
Deep
Carbon
Face
Gland Bolt
Holes

Fig. 9.35 Mechanical seals

(Courtesy A.W. Chesterton Co.)

Mechanical seals are always flushed in some manner to lubricate the seal faces and minimize wear. This may be the liquid being pumped if it is fresh water. If fresh water is used, it is connected from the high pressure side and back to the stuffing box low pressure side. In some lift stations where fresh water is not available, the wastewater is used in this manner but it must be filtered. Another method is to use fresh water from an air gap system. Still another way of lubricating the seal is to use a spring-loaded grease cup.

Whatever method is used, it must be inspected frequently. The seal water is adjusted to 5 psi above maximum discharge pressure to keep the wastewater and grit from entering the seal housing and contaminating the seal faces. Grease cups must be kept full at all times and inspected to make sure they are operating properly.

When a pump is fitted with a mechanical seal, it must never run dry or the seal faces will be burned and ruined. Mechanical seals are not supposed to have any leakage from the gland. If a leak develops, the seal may require relapping or it may have to be replaced.

Repair or replacement of mechanical seals requires the pump to be removed and dismantled. Seals are quite delicate and special care must be taken when installing them. Mechanical seals differ widely in their construction and installation; and individual manufacturer's instructions must be followed. Due to the complexity of installing mechanical seals, special tools and equipment are needed as well as a quaified pump mechanic.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 230.

9.54A Why should a pump with a mechanical seal never be allowed to run dry?

9.54B What should be done when a mechanical seal develops a leak?

9.55 Bearings

Pump bearings usually should last for years if serviced properly and used in their proper application. There are several types of bearings used in pumps such as ball bearings, roller bearings, and sleeve bearings. Each bearing has a special purpose such as thrust load, radial load, and speed. The type of bearing used in each pump depends on the manufacturer's design and application. Whenever a bearing failure occurs, the bearing should be examined to determine the cause and, if possible, to eliminate the problem. Many bearings are ruined during installation or startup. This section is a guide to identify types of bearing failures, causes, and preventive measures.

Bearing failures discussed are:

1. Fatigue failure,
2. Contamination,
3. *BRINELLING*[7],
4. False brinelling,
5. Thrust failures,
6. Misalignment,
7. Electric arcing,
8. Lubrication failure, and
9. Cam failure.

The following section is published with the permission of the Fafnir Bearing Company, Division of Textron, New Britain, Connecticut, from a publication on *HOW TO PREVENT BALL BEARING FAILURES.*

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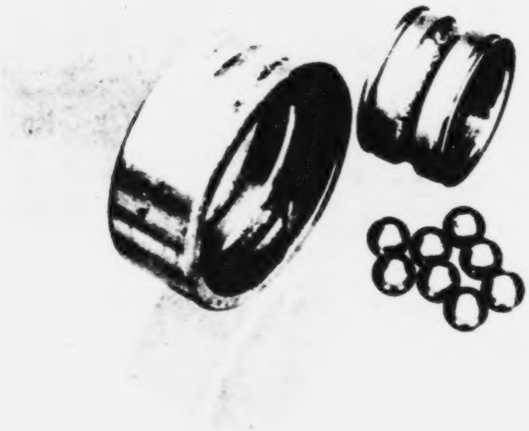
[7] *Brinelling. This type of bearing failure appears as tiny indentations (dents) high on the shoulder of the race.*

FATIGUE FAILURE

1. IDENTIFICATION



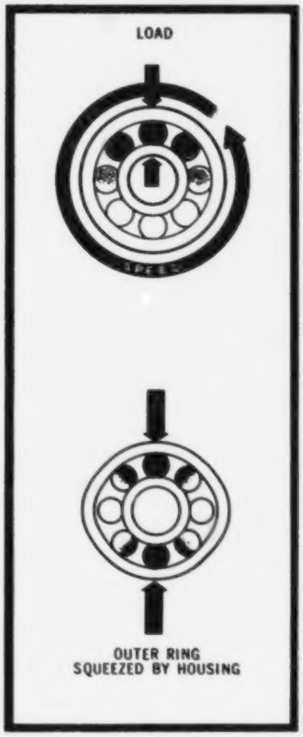
FLAKING OR SPALLING OF RACEWAY

Spalling is caused by a granular weakening of the bearing steel. The failure begins as a small fracture of the steel's internal structure. This fracture progresses to the surface of the race where particles of metal flake away as shown in the photograph.

NOISY RUNNING OF THE BEARING

Because of the rough race surface and the loose metal chips, there will be an increase in bearing vibration and noise.

2. CAUSE



NORMAL DUTY

As outlined in the introduction, a bearing has a life expectancy which depends upon load and speed. Calculations, based upon laboratory testing and field experience, have been set up to determine, fairly accurately, the life span of a group of bearings of a given size. The fatigue failure, as outlined above, is the result of a bearing "living out" its normal life span. The flaking of the races is caused by the combined effect of load and speed. In any rotating or oscillating ball bearing, there is a constant flexing or deflection of the ring and ball material under the load. Speed determines how often the flexing occurs while load determines the actual amount of stress under which the bearing steel operates. Assuming good machine design, satisfactory lubrication, and sound maintenance practices, it is load and speed that will, over a long period of time, cause eventual failure.

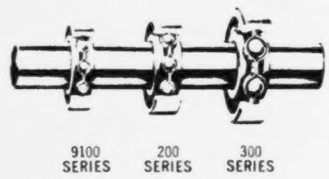
OVERLOAD ON THE BEARING

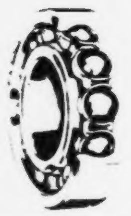
Premature failure of the bearing may result from the bearings being either radially or axially loaded beyond its normal capacity. Excessive operating load is not, however, the only reason for bearing overload. Overload may also occur due to abusive operating conditions as outlined below:

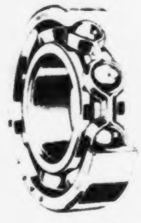
1. If a bearing with insufficient internal clearance (the space between balls and races) is mounted on a shaft with an excessively heavy press fit, the bearing will operate with increased friction and torque. This is because, with the outer-ring held firmly, the inner ring has been expanded, "pinching" the balls between the two rings.

2. If the bearing housing is out-of-round, the outer ring will tend to conform to the shape of the housing. This will exert a localized pressure on the ball contact area in addition to the normal pressure imposed by the operating work load.

3. PREVENTIVE MEASURES




MAXIMUM CAPACITY TYPE


CONRAD TYPE

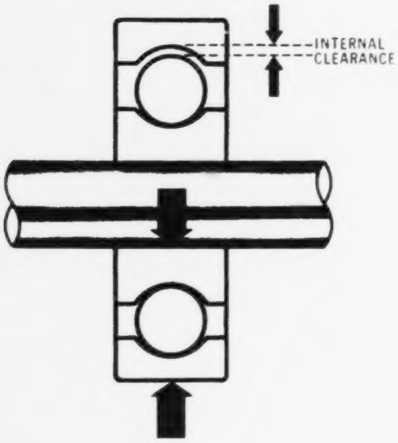
FOR NORMAL FATIGUE FAILURE

In the case of normal fatigue failure, the bearing has lasted its expected life. The remedy is simply to replace the bearing.

OVERLOAD FAILURE

Where overload is the cause of a premature fatigue failure, several alternatives are open:

1. Redesign to permit incorporating a bearing with greater capacity. There are extra-light, light, medium, and double row series bearings available in the same shaft sizes. The heavier series have thicker ring sections and larger balls for greater capacity. Also available for higher radial capacity is the maximum capacity type of bearing. This has exactly the same dimensions as the standard deep-groove Conrad type with the added advantage of more balls which are introduced through loading slots in the rings. These extra balls give this bearing increased radial capacity but the loading slots ground into the races restrict the thrust capacity of the bearings.



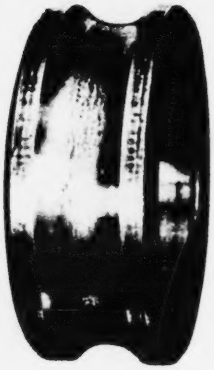
2. The load may be decreased to prolong the life of the bearing.

3. Housings should be gaged for out-of-roundness and machined or ground to proper symmetry and size. This insures that the outer ring will not be "pinched" or "squeezed" resulting in an overload condition.

4. If the failure is caused by an overload imposed by inner ring expansion, either the shaft fit may be made looser by regrinding it to proper size or, in the event of thermal expansion, a bearing with looser internal fit (more clearance between balls and rings) may be recommended.

CONTAMINATION

1. IDENTIFICATION

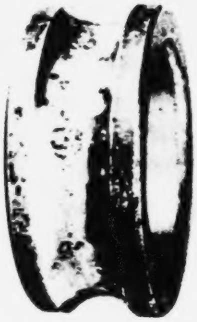


◄ SCORING, PITTING, SCRATCHING

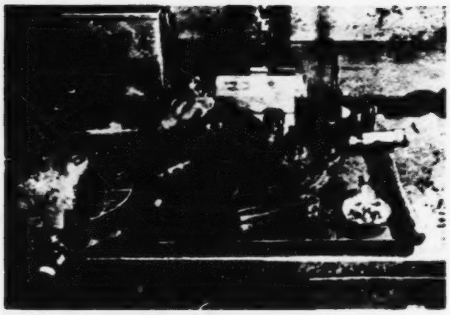
In a failure caused by the entrance of contaminants into the bearing, there may be a number of identifying earmarks. Where larger particles of dust or dirt are present, there will be scratches and pits around the periphery of the race with corresponding scoring of the ball. Where the contamination is in the form of very fine abrasives such as glass powder, graphite, or dust impregnated lubricants, the impurities will act as a lapping agent altering the appearance of balls and raceways. This type of failure may be characterized by intermittent noise in the bearing. The actual presence of dirt in the bearing is the best indication of this type of failure.

RUST ►

Where rust forms on the O.D. of the outer ring, it will not usually interfere with the bearings' operation in standard application, but rust in the bore is more serious because of the importance of inner-ring-to-shaft fit. Rust in the raceways or on the ball surfaces precludes any further usage of the bearing.

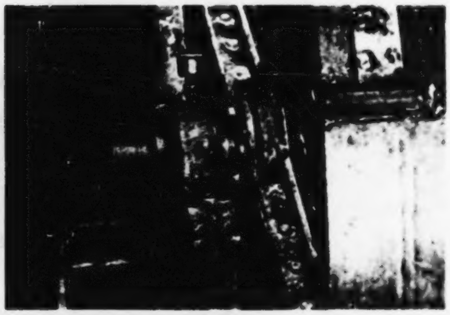


2. CAUSE



DIRTY OR DAMP SURROUNDINGS

Most bearing failures may be traced to some sort of contamination. Dirty working conditions are one of the bearing user's greatest problems. Thousands of dollars a year may be saved simply by taking certain precautions (outlined below) against the entrance of impurities into bearings. Internal clearance in precision bearings is measured in ten thousandths of an inch. Most dirt particles are larger than one thousandth of an inch, so hard particles will indent the race and ball surfaces when the bearing rotates.



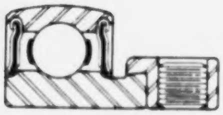
ABRASIVE WASTE MATERIALS

In many machinery applications—farm implements, industrial grinders, wood working tools and many others—there may be an abrasive waste product which infringes upon the efficient operation of bearings. This would also apply where coolants, washing solutions, acids, or other liquids are used around a bearing application.

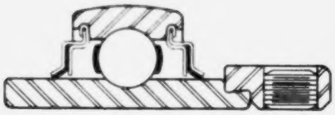
3. PREVENTIVE MEASURES

AVOID DAMAGE FROM ABRASIVE WASTE PRODUCT

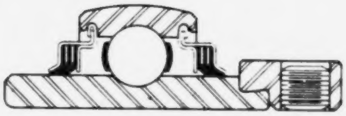
Where a manufacturing process involves an abrasive by-product, it is essential that the bearing be properly sealed. Where failures of this kind prevail, a more efficient seal is required. In applications where extreme contamination is encountered, a sealed housing or shroud may be incorporated to protect the bearing.



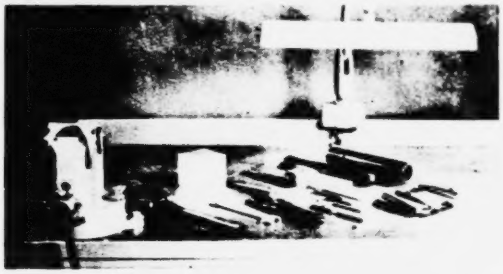
PLYA SEAL



"R" SEAL



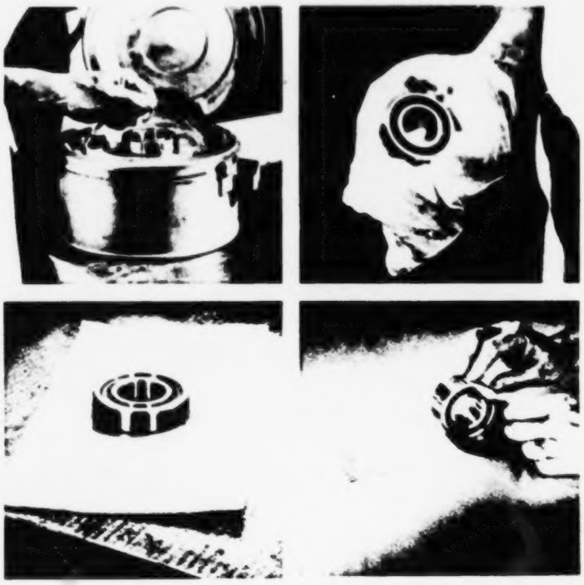
TRI-PLY SEAL



CLEAN WORKING SURROUNDINGS

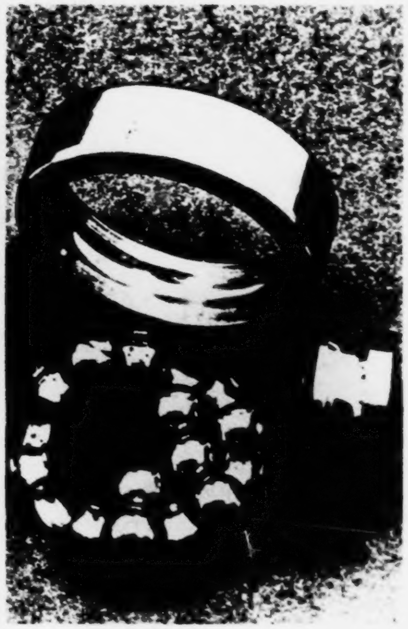
Clean tools, dirt-free working area, and clean dry hands are essential to prevention of bearing failures. Careful control of washing procedures, relubrication, and handling of bearings according to recommended practices will alleviate many of the problems of contamination failures. The following is a list of procedures outlined by the Anti-Friction Bearing Manufacturers Association for the control of cleanliness in the handling of bearings:

1. *Work with clean tools in clean surroundings.*
2. *Remove all outside dirt from housing before exposing bearings.*
3. *Handle with clean, dry hands.*
4. *Treat a used bearing as carefully as a new one.*
5. *Use clean solvents and flushing oils.*
6. *Lay bearings out on clean paper and cover.*
7. *Protect disassembled bearings from dirt and moisture.*
8. *Use clean, lint-free rags if bearings are wiped.*
9. *Keep bearings wrapped in oil-proof paper when not in use.*
10. *Clean inside of housing before replacing bearings.*
11. *Install new bearings as removed from packages.*
12. *Keep bearing lubricants clean when applying and cover containers when not in use.*



BRINELLING

1. IDENTIFICATION



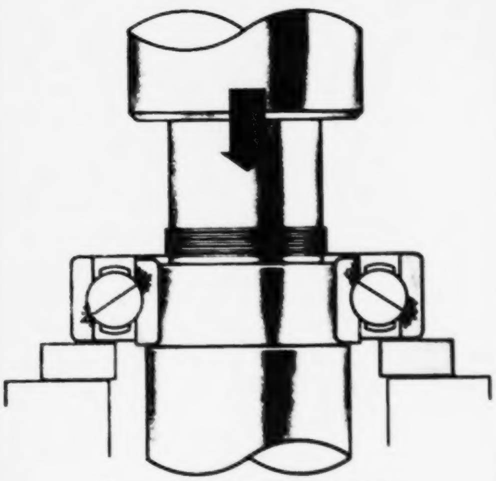
MOUNTING INDENTATIONS
(THRUST FORCE)

This failure will appear as tiny indentations (sometimes barely discernable to the naked eye) high on the shoulder of the race. The dents will be angularly spaced in correspondence to the ball spacing. There will be a corresponding indentation of lesser magnitude on each ball. When the bearing is radially loaded, the brinnels on the race shoulder may not interfere with the ball tracks. In this event, the dent on the ball will cause the failure. In the later stages of failure, spalling or chipping may result. The race shoulders can be inspected (with a microscope if available) to see if a spalling failure may not have resulted from initial brinelling.

RADIAL INDENTATIONS
(RADIAL FORCE)

The indentations have the same general appearance as those mentioned above except that they appear in the center of the race instead of on the shoulder. This type of brinell is less common than the mounting brinell because, under the sharp impact of radial shock load, the rings may fracture beneath the force.

2. CAUSE



INCORRECT ARBOR PRESS DISMOUNTING

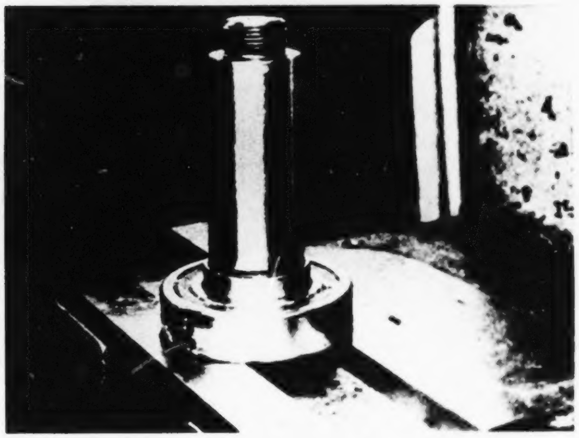
FORCE INCORRECTLY EXERTED

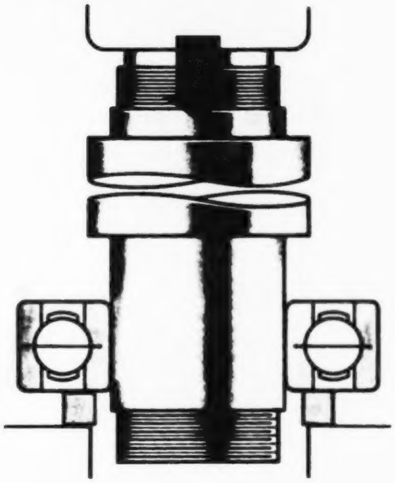
Indentations high on the race shoulder are caused in mounting (or dismounting) where force is applied against the unmounted ring. When mounting a bearing on a shaft with a very close fit, pushing of the outer ring will exert an excessive thrust load bringing the balls into sharp contact with the race shoulder, causing a brinell.

RADIAL SHOCK LOAD

Radial indentations are caused by a shock load imposed radially on a non-rotating bearing. This may be imposed by hitting the bearing with a hammer or by an operating shock load exerted on a static shaft.

3. PREVENTIVE MEASURES



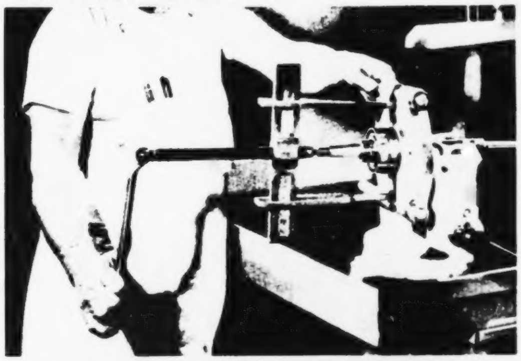


PROPER MOUNTING PROCEDURE

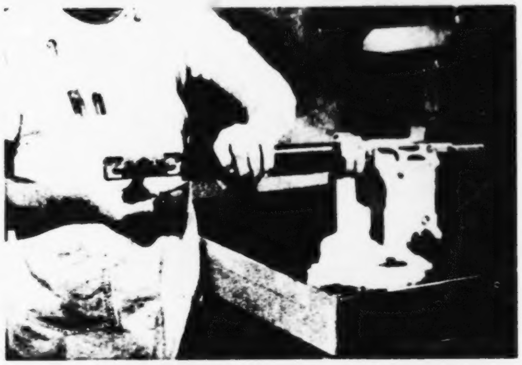
In mounting a bearing, force should always be exerted against the ring being mounted. In other words, when mounting the bearing on a shaft, the pressure should be applied against the inner ring. When mounting in a housing press against the outer ring. In other words the ring having the tighter fit (usually the ring which will rotate in application) should be pushed.

Be sure when mounting a bearing to apply the mounting pressure slowly and evenly.

OTHER METHODS OF MOUNTING OR DISMOUNTING



Dismounting with bearing puller and puller jaws.

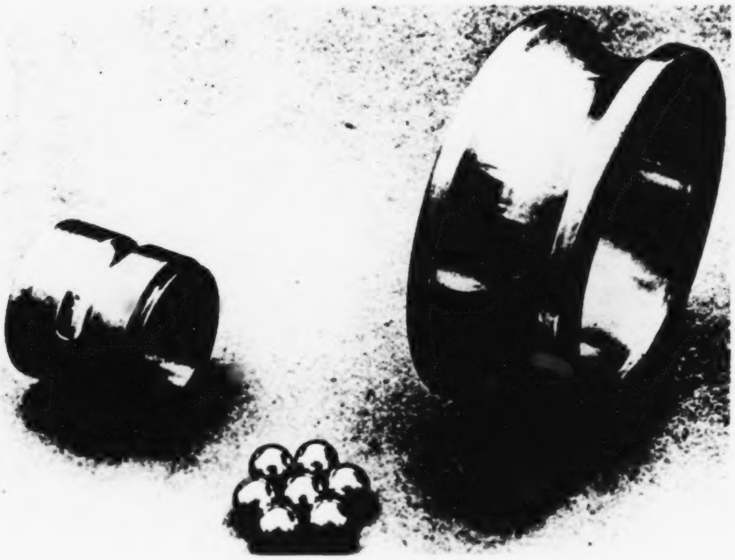


Mounting with tubular drift.

Dismounting with semi-circular drift.

FALSE BRINELLING

1. IDENTIFICATION



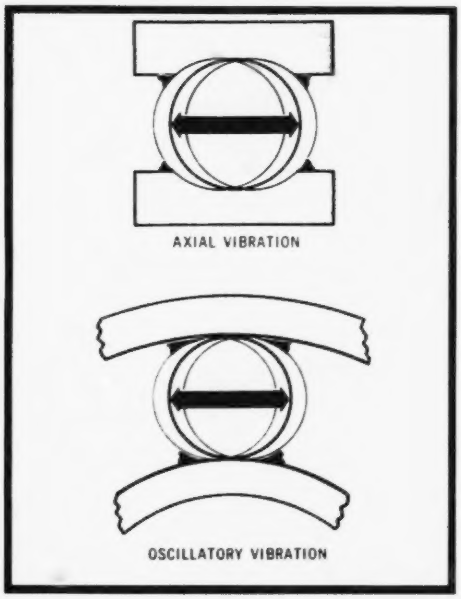
AXIAL INDENTATIONS

This type of brinelling will appear as elliptical impressions which run axially across the races. There will be a build-up of reddish lubricant around each brinell. Also, the brinells will be spaced corresponding with the ball spacing.

CIRCUMFERENTIAL INDENTATIONS

This will appear exactly as the brinell above except that the impression will be wider in a circumferential direction.

2. CAUSE



VIBRATION IN A STATIC BEARING

False brinelling is caused by a vibration of the balls between the races in a stationary bearing. This vibration may be either axial or circumferential. The appearance of the brinells will tell you which. As the ball vibrates between the races, the lubricant is forced out of the contact area between ball and race. The failure is the result of a breakdown of the lubricant causing metal-to-metal contact and localized wear of balls and races. The wearing action causes the formation of a fine reddish brown powder, iron oxide. The oxide impregnates the lubricant and provides an abrasive compound which will polish the balls and races if the bearing is put into operation. The indentations themselves will result in a rough and noisy operation of the bearing. Vibration in a bearing may be caused by a number of factors. Transporting mounted, but unlocked, bearings can result in a false brinell failure. A very common cause of this failure exists where a machine is "down", and the bearings are subjected to static vibration by other machinery which is running in the immediate area.

3. PREVENTIVE MEASURES

CORRECT THE SOURCE OF VIBRATION

The source of agitation—loose parts, non-precision machinery, rough transportation—may be corrected so that vibration is alleviated.

LOCKING THE BEARING

In the transportation of bearings, if a light thrust load (imposed by springs or rubber pads) can be applied to bring all of the balls into contact with the races, this type of failure can be avoided.

ALL SURFACES ADEQUATELY LUBRICATED

Where bearings are oil lubricated and employed in units that may not be in service for extended periods, the equipment should be set in motion periodically in order to spread the lubricant over all bearing surfaces. Intervals of 1 to 3 months should suffice.

TIGHT INTERNAL FIT-UP

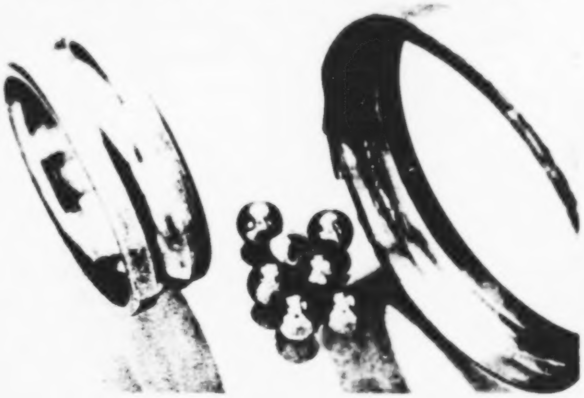
Sometimes a bearing with line-to-line contact between rings and balls will alleviate a false brinell failure. Great care should be taken, however, that a tight internal fit is satisfactory from an operation point-of-view.

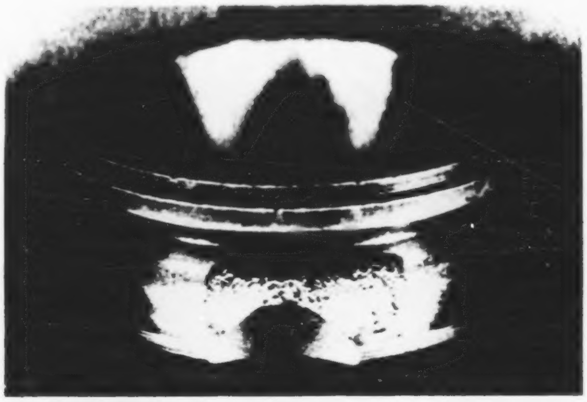
LOW VISCOSITY LUBRICANT

False brinelling is more common with stiffer lubricants. This failure is less apt to occur where oil or a light viscosity grease is used, because the more liquid characteristics make it difficult for the lubrication to be forced out of the contact area.

THRUST FAILURES

1. IDENTIFICATION





COUNTERBORED BEARING

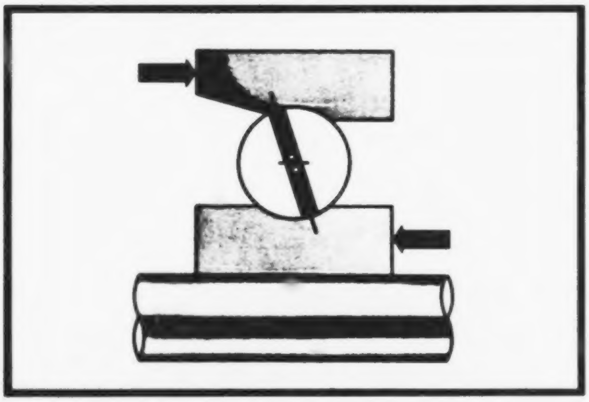
There will be a breakdown of the counterbored shoulder of the bearing which may result in fracture of the ring. The balls will be banded from riding up against the shallow shoulder. Also the bearing may become disassembled during service.

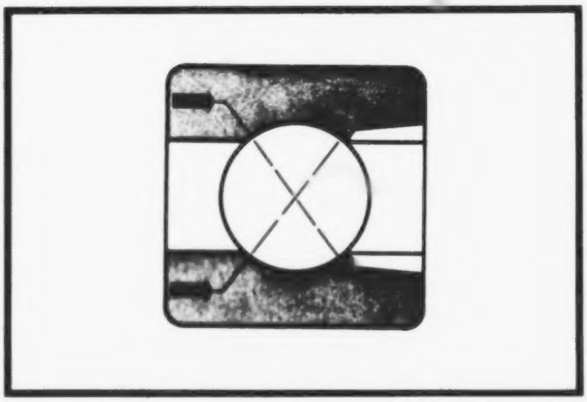
MAXIMUM CAPACITY

Bearings with filling slots are not recommended for heavy thrust loading because, as the balls pass over the inner ring and outer ring notches, they may become nicked or dented. This in turn may cause spalling of the races (probably in the vicinity of the loading slot).

2. CAUSE

IMPROPER MOUNTING OR MISAPPLICATION AS INDICATED:





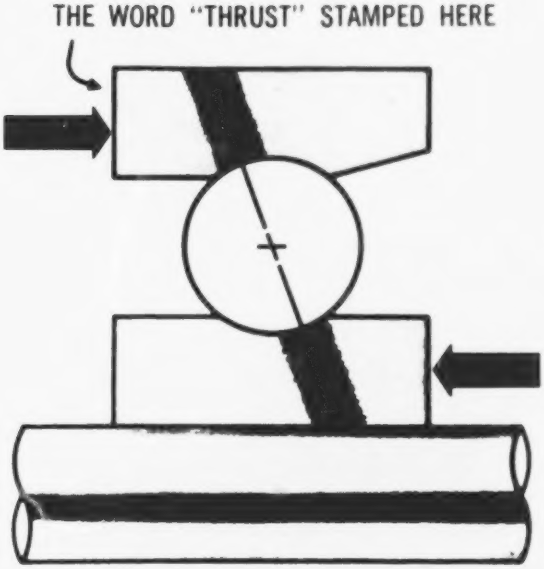
COUNTERBORE FAILURE

A thrust failure is caused either by mounting the bearing backwards (so that the load is carried against the shallow shoulder) or by putting a counterbored bearing into a two-directional thrust application.

MAXIMUM CAPACITY FAILURE

This failure results from excessive thrust loads on a bearing not primarily intended for heavy thrust loads. From the diagram it is evident that too much thrust load from either direction will cause interference between the balls and one of the loading slots which are ground in both the inner and outer rings.

3. PREVENTIVE MEASURES



COUNTERBORE FAILURE

The remedy here is simply to mount the bearing correctly so that the ball has full-shoulder support on both the inner and outer ring. Remember that the outer ring counterbore bearing will take thrust against the inner ring on the counterbored side of the bearing and the outer ring on the side opposite the counterbore. The word THRUST will be stamped on the outer ring face showing the proper thrust surface.

MAXIMUM CAPACITY FAILURE

This bearing is designed for heavy radial or combined radial-thrust loads; not for pure thrust loading. (It is generally recommended that no more than 60 percent of the accompanying radial load on the bearing be applied in thrust.) If thrust capacity is required, a more suitable bearing (a Conrad type, a counterbored bearing, or possibly a duplexed pair of bearings) must be selected.

MISALIGNMENT

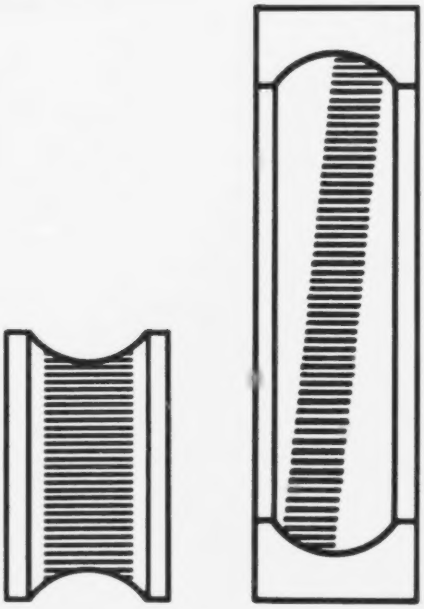
1. IDENTIFICATION

BALL PATH

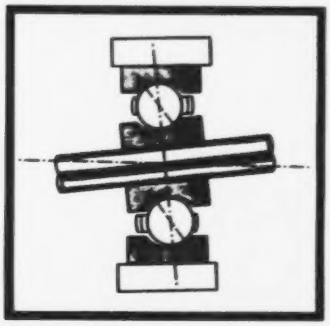
In a bearing with one of its rings misaligned in relation to the other, the ball path will run from one side of the race to the other around one half the circumference on the nonrotating ring. The rotating ring will have a wide ball path. Because of the extra pressure imposed on the bearing due to misaligned conditions, an excessively high temperature may develop which will discolor the ball tracks and balls and destroy the lubricant.

RETAINER

The purpose of the retainer is to space the balls and guide them in a true path around the raceway. Where a ring is misaligned, the balls are driven up against the race shoulder, and a stress point is set up between the ball and its retainer pocket. The pocket will flex with the possibility of retainer fracture in advanced stages of failure.

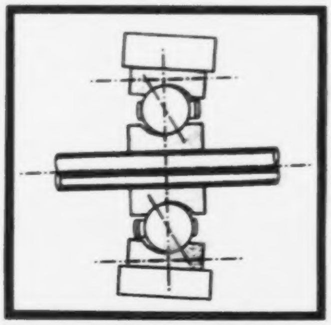


2. CAUSE



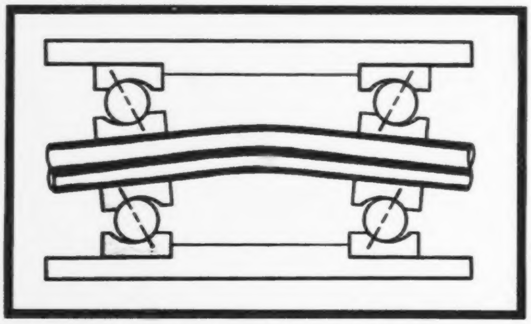
SHAFT MISALIGNMENT

Misalignment of the shaft in relation to the housing causes an overload of the balls which will result in the failure described.



MISALIGNMENT OF THE HOUSING

Housing misalignment may be caused either by the housings being cocked with the plane of the shaft or the housing shoulder being ground out-of-square so that it forces the outer ring to cock in relation to the inner. It may also result from settling of the frames or foundations.

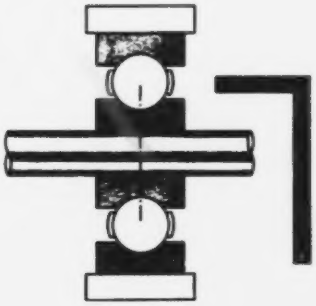


BOWING OF THE SHAFT

Shaft bowing may be caused by any one of the following:

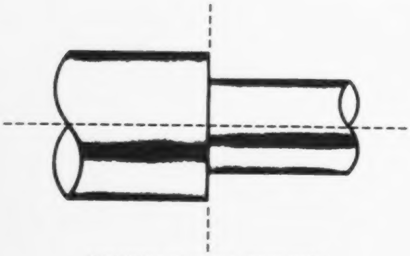
(a) Bent as a result of improper handling
(b) Overhung load exceeding shaft capacity
(c) Initial shaft bowing due to grinding inaccuracies
(d) Shaft shoulders ground out-of-square with the shaft centerline which will, by cocking the inner ring, force a bowing of the shaft.

3. PREVENTIVE MEASURES



SHAFT

The shaft should be gaged to make sure that it is concentric and straight. Heavy overhang loads should be lightened or moved closer to the bearing. If the shoulders are out-of-square, they should be reground and gaged so that they are perpendicular to both the bearing seat and the shaft centerline.



SQUARING-UP SHAFT SHOULDERS

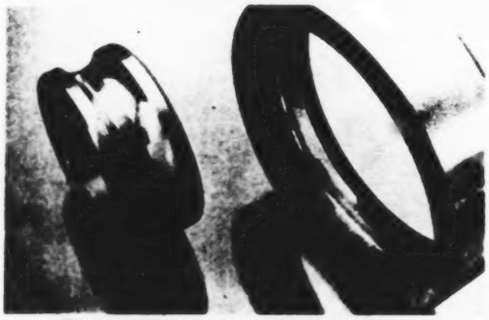
HOUSING

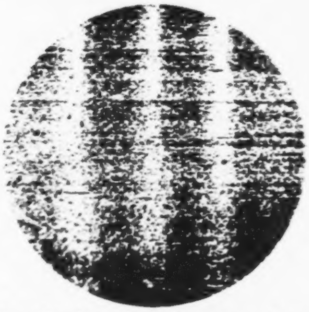
The remedy is to dimensionally check and insure that both housing bores are true with each other.

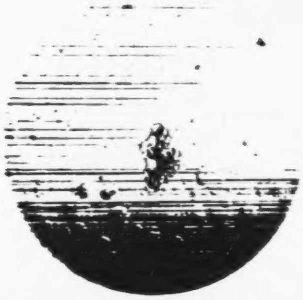
234

ELECTRIC ARCING

1. IDENTIFICATION


Electro-etching on both inner and outer ring.


Magnification of granular race surface.


Magnification of electric pitting.

ELECTRIC ARC EROSION

When an electric current passing through a bearing is broken at the contact surfaces between races and balls, arcing results which produces high temperatures at the localized points. Each time the current is broken in its passage between ball and race a pit is produced on both parts. Eventually the phenomenon known as fluting develops, (see photograph) and as it becomes deeper, noise and vibration result.

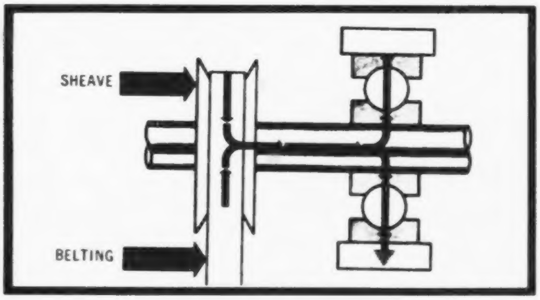
GRANULAR RACE SURFACES

If the current is of higher amperage intensity, such as a partial short circuit, the next phase of the failure will show up as a rough granular appearance in the ball track.

PITTING OR CRATERING

Heavy jolts of high amperage charges will cause a more severe failure resulting in the welding of metal from the race to the ball. These nipples of metal on the ball will, in turn, cause a cratering effect in the race. This phenomenon will result in noise and vibration in the bearing.

2. CAUSE



STATIC ELECTRICITY

Static electricity usually emanates from charged belts or from manufacturing processes using calendar rolls (leather, rubber, cloth, paper).

The current is carried from the belt to the pulley or sheave; from the sheave to the shaft; and through the shaft to the bearing and thence to the ground.

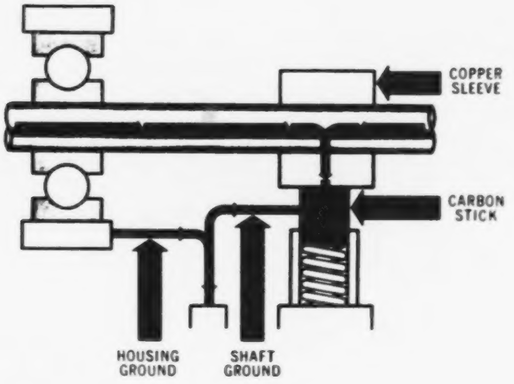
ELECTRIC LEAKAGE

Faulty wiring, inadequate or defective insulation, or loose rotor windings on an electric motor are all possible sources of current leakage. Either AC or DC currents will damage bearings.

SHORT CIRCUIT

Wires which are crossed or contacted by a common conductor will cause a short circuit and may result in a passage of current through the bearing.

3. PREVENTIVE MEASURES

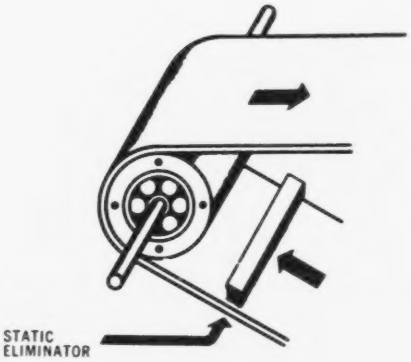


SHUNTS AND SLIP RINGS

Where there is a passage of current through a bearing and the source of the current cannot be corrected, a shunt in the form of slip ring assembly may be incorporated to by-pass the current around the bearing.

CORRECTIVE MAINTENANCE

Be sure wiring, insulation, or rotor windings are sound and all connections are properly made. In arc welding, great care should be taken that the welding apparatus is not grounded on something which will circulate the current through the bearings.



GROUNDING BELTS

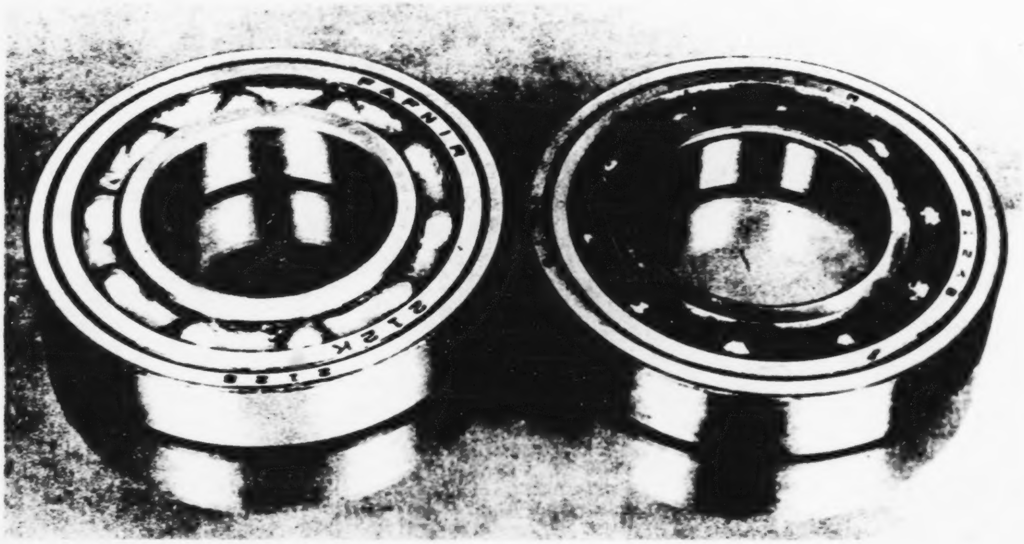
For elimination of static charges, either the belt should be grounded, or the belting should be changed to a less generative material.

INSULATING BEARINGS

Sleeves of nonconductive material may be used either between the outer ring and housing or between inner ring and shaft, depending upon the source of current.

LUBRICATION FAILURE

1. IDENTIFICATION



New bearing with fresh grease on the left as contrasted with lubrication breakdown on the right.

GREASE APPEARANCE

If the grease is stiff or caked and changed in color, it indicates lubrication failure. The original color will usually turn to a dark shade or to jet black (see photo.) The grease will have an odor of burnt petroleum oil. Lubricity will be lost as a result of lack of oil. In cases of Lithium base greases the residue appears like a glossy brittle varnish which will shatter when probed with a sharp instrument.

ABNORMAL TEMPERATURE RISE

Probably the first indication of lubricant failure is a rapid rise from the normal operating temperature. Test by hand is not necessarily conclusive since normal operating temperature may exceed the bearable limit of about 120° F.

NOISE

Lack of lubrication is soon accompanied by a whistling noise coupled with this rise in temperature. If not corrected the bearing temperature will continue to rise and the intense heating will reduce the bearing hardness.

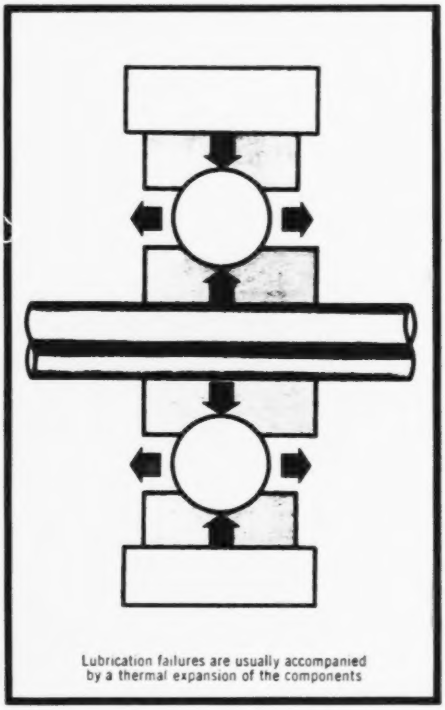
BEARING DISCOLORATION

A brownish or bluish discoloration of the races and balls indicates that the bearing operating temperature was excessively high to the extent that the bearing lost its physical properties and was no longer operable.

RETAINER FAILURE

The bearing part that first indicates distress in lubrication failures is usually the retainer where the greatest amount of rubbing action takes place.

2. CAUSE



Lubrication failures are usually accompanied by a thermal expansion of the components

DIRTY LUBRICATION

The Fafnir Bearing Company filters ball bearing lubricants as many as five times to insure their purity. Contaminants found in lubricants often act as an abrasive compound which will lap or polish ball and race surfaces, increasing the probability of early failure.

TOO MUCH LUBRICANT

A very common error in the maintenance of machinery is the tendency to over-lubricate. If the bearing reservoir is kept constantly full of grease, the friction heat developed within the lubricant will cause its rapid deterioration.

INADEQUATE LUBRICATION

Heat will result from under-lubrication, also. Where there is inadequate lubricant to cover all metal surfaces, friction will result in heat-up of the bearing.

WRONG KIND OF LUBRICANT

After experimentation with many types of lubricants, the equipment manufacturer recommends those which he feels will provide ideal lubrication life under given operation conditions. Inasfar as availability allows, you should use the same lubricant or its equivalent. This way you are assured of the correct lubricant in addition to avoiding the problems associated with mixing two types of grease. (Many greases are incompatible and, although completely adequate when used individually, may prove unsatisfactory when mixed.) Selection of the correct lubricant, therefore, is very important in achieving maximum efficiency and endurance from the application.

OTHER FAILURE MODES

In many instances lubricant failure will accompany the bearing failures described in this manual. The primary cause of lubricant failure is from the high temperatures developed when excessive loads exceed the strength of the lubricant film. Lubricant changes might reduce the failure rate but the proper course of action is to eliminate the primary cause for the lubricant breakdown.

3. PREVENTIVE MEASURES

AVOIDING DIRTY LUBRICANT

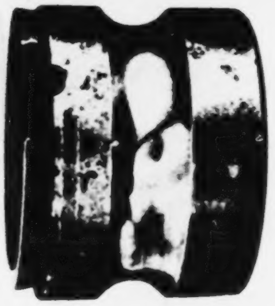
Always keep grease containers covered. Dust particles in the air can contaminate the lubricant. Use a clean rust-resistant spatula for relubricating open bearings. When relubricating bearings through a grease fitting, always wipe off both the fitting and the nozzle of the grease gun. Any steps which you can take to keep lubricants clean will pay off in longer bearing life.

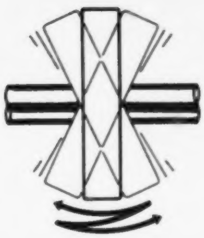
AMOUNT OF LUBRICANT

When you are unsure of the amount of grease or oil for proper lubrication, the Fafnir engineering department should be consulted. In standard applications, it is generally recommended that the bearing should be greased one third to one half full.

CAM FAILURE

1. IDENTIFICATION





BROKEN CAM

The eccentric cam on the wide inner ring bearing will have a wedge-shaped fracture in it. Depending upon the degree of failure the fracture may extend into the cam or all the way into the race of the bearing.

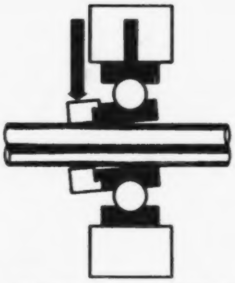
BALL PATH

Because the inner ring will be cocked on the shaft, the ball path will have a wobbly appearance similar to that on a misaligned bearing. The ball path will run from one side of the non-rotating ring to the other for one half of the perimeter of the race.

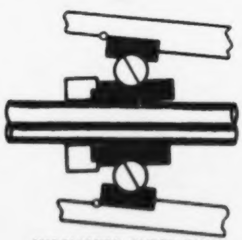
WOBBLE OF BEARING

While in application, the rotating bearing will wobble from side to side. If the housing is flexible enough, the whole assembly may flex with the rotation of the bearing.

2. CAUSE



SHAFTING BELOW SUGGESTED TOLERANCE LEVELS



MISALIGNED OUTER RING

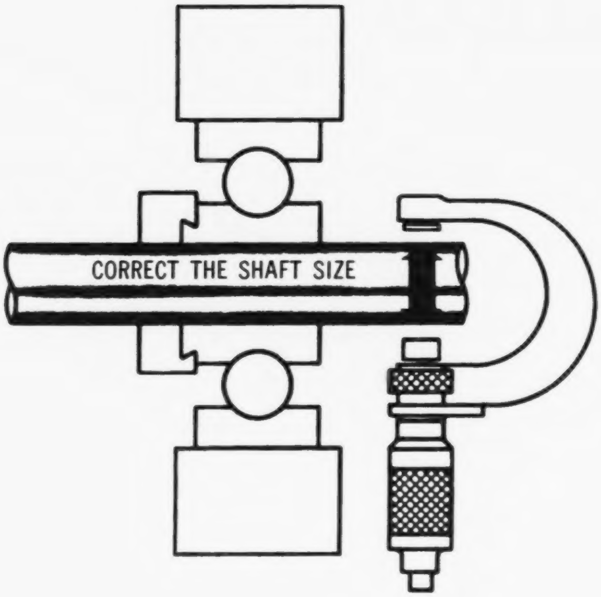
UNDERSIZED SHAFTING

The eccentric cam locking collar was originally developed to provide a means of securing a bearing to low cost cold-rolled shafting. It must not be assumed, however, that the bore-to-shaft fit is without some tolerance control. Fafnir has set up tolerance limits (see Preventative Measures for recommended limits) for shaft fits on wide inner ring bearings, which must be maintained if this type of failure is to be avoided. When the eccentric collar is locked to its inner ring mating cam on an undersized shaft, the inner ring becomes cocked on the shaft. (Remember that, for proper locking action, the collar should always be turned in the direction of shaft rotation.) When the machinery is turned on, the inner ring tries to realign itself with the shaft as it rotates. This provides a levering action with a stress area where the collar grasps the inner ring. Eventually this stress will fracture the inner ring cam.

OUTER RING UNABLE TO ALIGN

The same problem exists where an outer ring with a self-aligning feature is clamped so firmly into the housing, that it cannot take advantage of its self-aligning feature. This may happen where the bearing is forced with an excessively tight fit into a cast housing or where pressed steel housing halves are bolted together before the bearing has assumed its initial alignment.

3. PREVENTIVE MEASURES



CORRECT THE SHAFT SIZE

Where a failure occurs, the shaft should be checked with a micrometer caliper to determine how much under normal tolerance the shaft diameter falls. Then, either a new shaft should be obtained or the old one should be plated and ground to correct size.

The following are the recommended tolerances for shafting:

BEARING BORE	SHAFT TOLERANCES
½" to 2"	.0000 to −.0005
2$\frac{1}{16}$" to 3$\frac{15}{16}$"	.0000 to −.001
4" and over	Because of heavy loading, engineering department should be consulted.

ALLOWING THE BEARING TO ALIGN

Fafnir has incorporated a self-aligning feature—a spherical outer ring—into its wide inner ring line to compensate for a certain amount of initial misalignment. The proper mounting procedure is to: (1) Align the bearing in its housing and slide unit into position on the shaft (2) bolt the housing tightly to its mounting support (3) engage and tighten locking collar and set screw.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 230.

9.55A What are the different types of bearings used in pumps?

9.55B What should be done whenever a bearing failure occurs before its expected replacement time?

9.55C List as many different types of bearing failures as you can remember.

9.55D What can cause contamination failure of a bearing and how can it be prevented?

9.55E How can bearing failures from misalignment be prevented?

9.55F How can bearing lubrication failures be identified?

9.56 Couplings

9.561 Purpose of Couplings

Pumps must be driven by some means in order to operate. Electric motors, gasoline or diesel engines, air pressure, hydraulic pressure, steam pressure, and other sources of power are used to drive pumps. Electric motors and gasoline or diesel engines are the most common source of power used in the wastewater field. In order to connect these drivers to the pump, a coupling is needed (Fig. 9.36). There are several ways to couple a pump and driver together. Some of the most common methods are:

1. Direct coupling,
2. Belt-driven,
3. Flexible shafting, and
4. Close-coupled.

Each method has its advantages and limitations and is used for a specific purpose.

9.562 Direct Coupled

Pumps and drivers are directly coupled when they are mounted on a common base, and the speed of the driver is the same as that of the pump. The shaft of the pump has one of the coupling ends, and the driver has the other end mounted on it. The coupling may be either rigid (clamp and compression) or flexible. A flexible coupling is a device to connect two shafts together, transmit torque, and at the same time allow for *VERY SLIGHT* misalignments. The main functions of all flexible couplings are:

1. To transmit power efficiently and effectively from one shaft to the other,
2. To decrease wear on shaft bearings and driven equipment, and
3. To accommodate the slight shaft misalignments which develop in service.

Other functions of flexible couplings include:

1. To absorb shock loads and pulsations,
2. To dampen vibrations,
3. To accommodate load reversals,
4. To minimize initial backlash, and
5. To provide ease of installation and maintenance.

ALIGNMENT (Fig. 9.37)

When shafts are directly coupled, shaft alignment is extremely important. There are two types of shaft alignment:

1. Parallel, and
2. Angular.

The coupling also can have end float; that is, the shaft moves in and out. This has to be taken into consideration when installing a coupling. Misaligned shafts not properly coupled are subject to severe stresses and damage at bearings and seals.

With couplings that are properly machined, accurate alignment is achieved when the coupling faces are absolutely parallel as measured by feelers — a straight edge placed squarely across the rings of the coupling halves. Place the feelers at the top, bottom, near and far sides of the coupling junctions. Also place the feelers along the edge of the top and sides of the shaft. Proper alignment is accomplished by the use of wedges and *SHIMS*[8] under the pump or motor.

When installing a coupling, inspect it carefully. Should there be any misalignment, adjustment is made by installing wedges or shims until no variation is seen by the straight edge or feeler gage. Hold the pump half coupling stationary and rotate the driver 90 degrees at a time and examine the alignment. Insert shims as necessary to bring shaft into alignment. Make sure both couplings are the same diameter and are clean. The clearance between faces of coupling halves should be set so they cannot strike, rub, or exert a pull on either machine.

Different types of couplings have different tolerances for alignment. Usually tolerances range from .002 inches to .005 inches. Consult with the particular coupling manufacturer for the exact alignment needed. There are so many factors entering into the probable life of a coupling that it is impossible to predict the impact of misalignment on coupling life for every application. Any coupling which is stressed heavily with torque

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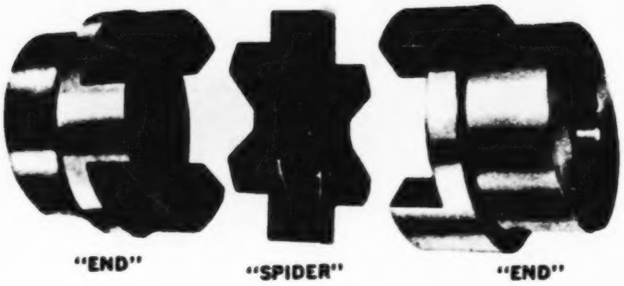
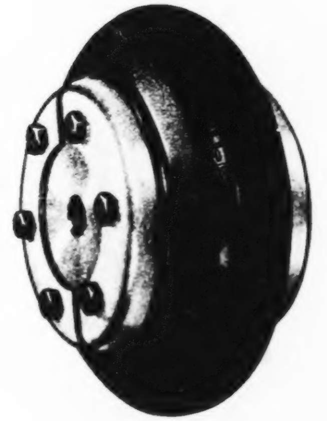
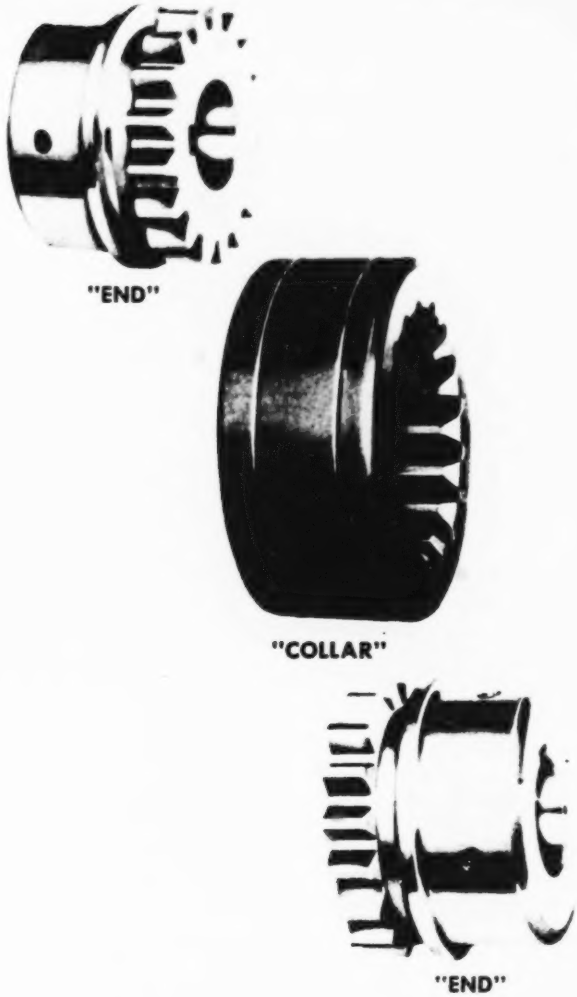
[8] *Shim. Thin metal sheets which are inserted between two surfaces to align or space the surfaces correctly. Shims can be used anywhere a spacer is needed. Usually shims are 0.001 to 0.020 inches thick.*


"END"
"SPIDER"
"END"

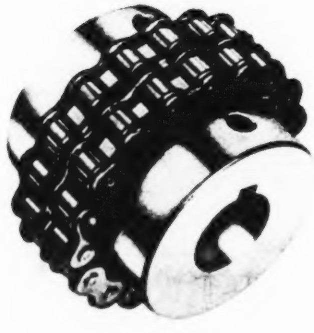
Flexible Saw



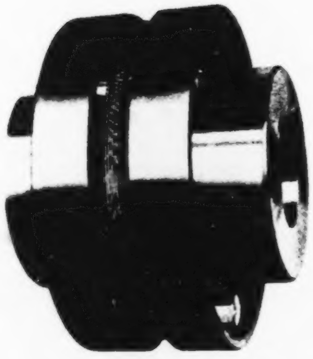
Tra-Flex


"END"
"COLLAR"
"END"

Gear



Chain



Disc

Fig. 9.36 Couplings
(Courtesy of Rexnord Inc., Milwaukee, Wisconsin)

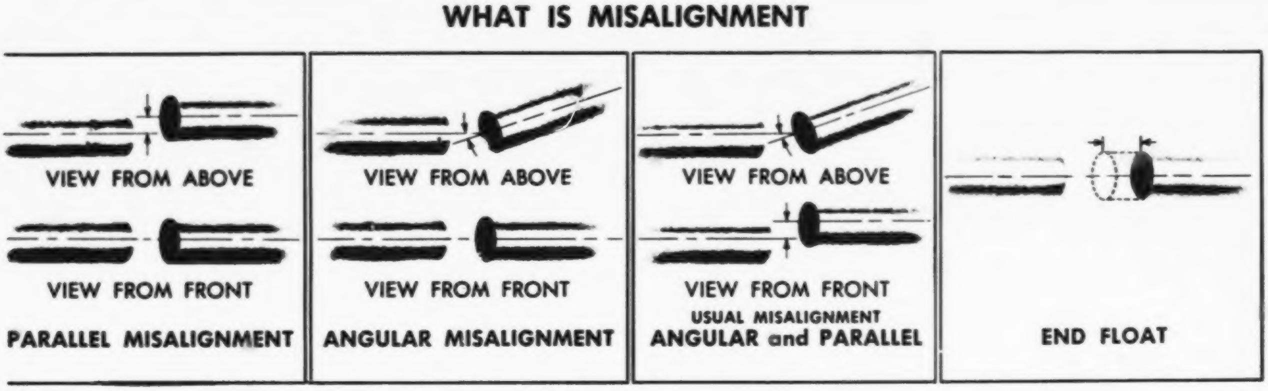


Fig. 9.37 What is misalignment?
(Courtesy of Rexnord Inc., Milwaukee, Wisconsin)

will have very little reserve left for misalignment conditions. On the other hand, if a coupling is lightly torqued, it would have a larger reserve left for misalignment. Also, a coupling traveling at a slow speed, such as used on the slow side of a gear reducer, can take relatively large misalignments over a long period of time. If a coupling is rotating at high speeds, it must be aligned with great care to provide maximum trouble-free service.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 230.

9.56A What is the purpose of a coupling?

9.56B List four common methods of coupling a pump and driver together.

9.56C What are the functions of a flexible coupling?

9.56D How can you tell if coupling alignment is proper?

9.56E What do you look for when inspecting clearances between faces of coupling halves?

9.563 Belt-Driven

Another method of connecting a pump to a motor or driver is with belts (Fig. 9.38). A pulley is mounted on the pump shaft and another pulley is mounted on the driver. One or more belts are installed connecting the two pulleys together.

The driver can be located above the pump or beside the pump in many different configurations. The pump shaft and motor shaft must be positioned so the pulleys can be aligned with the belts in a straight line. An advantage of driving a pump with belts is the speed ratios that can be achieved between the motor and pump; almost any speed is available. If this speed needs to be changed for any reason, it is only necessary to change a pulley.

V-belt drive pulleys are more commonly known as sheaves. Sheaves are normally made of cast iron or steel and machined to size. They can be single groove, two groove, three groove, or many more depending upon horsepower requirements. The grooves can be for A, B, C, D, or E belts. The letter designation is the cross section of the belt to be used; "A" being the smallest and "E" the largest. A and B belts are most commonly used.

There are many manufacturers of V belts and it is impossible to list each type and manufacturer available. There are standard belts, super belts, torque-flex belts, band belts, and many others. The best way to select belts is to contact your supplier, give the horsepower, speed, equipment driver, type of load, sheave diameters, and shaft diameters. If it is an existing installation, use the belt numbers found on the belt when reordering. If there is more than one belt installed, they must all be replaced at the same time and be a matched set so all belts will wear evenly.

When installing or replacing V belts, the motor and pump sheaves must be aligned. This means that the belt must run straight between the two pulleys without any angle. This can be achieved by placing a straightedge between the two pulleys and making sure that both are on the same plane. Another method is to use a string pulled across both pulleys, making sure that the string hits the pulleys at all points. The belts must be placed over the sheaves and in the grooves without forcing them over the sides of the grooves which would damage the belts.

With all belts in their proper grooves, adjust the centers to take up all slack until the belts are fairly taut. Start the drive and continue to adjust until the belts have only a slight bow on the slack side of the belt drive while operating under load. To determine proper adjustment of belts when the unit is not operating, turn power to unit off, tag and lock out. Adjust belt until there is ¾-inch of belt movement from hand pressure at the middle of the slack belt (Fig. 9.39).

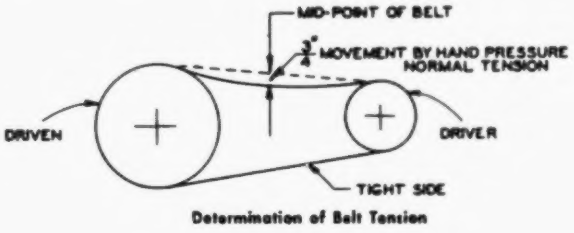
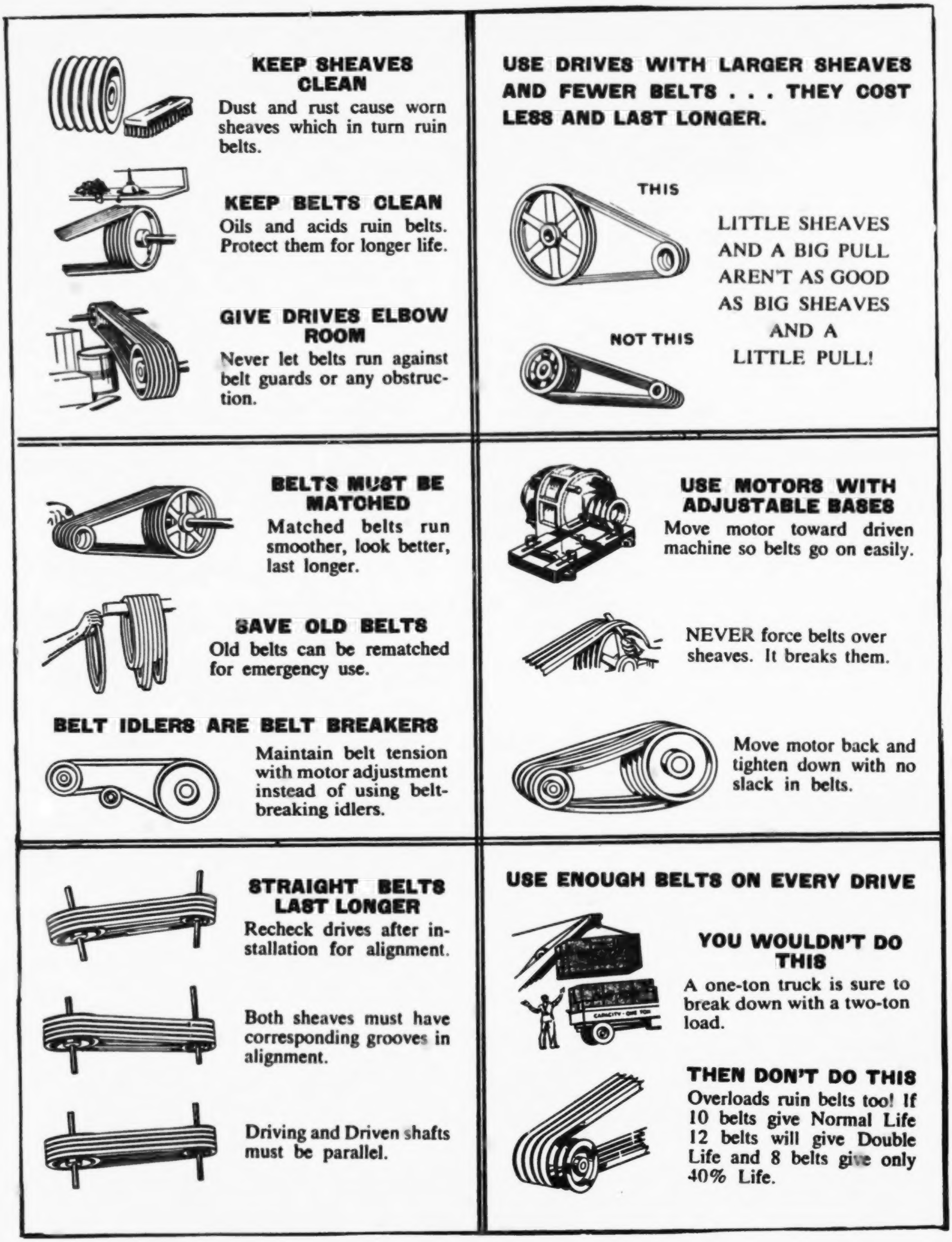

MID-POINT OF BELT
3/4" MOVEMENT BY HAND PRESSURE NORMAL TENSION
DRIVEN
DRIVER
TIGHT SIDE
Determination of Belt Tension

Fig. 9.39 Determination of belt tension
(Courtesy of Browning)



KEEP SHEAVES CLEAN

Dust and rust cause worn sheaves which in turn ruin belts.

KEEP BELTS CLEAN

Oils and acids ruin belts. Protect them for longer life.

GIVE DRIVES ELBOW ROOM

Never let belts run against belt guards or any obstruction.

USE DRIVES WITH LARGER SHEAVES AND FEWER BELTS . . . THEY COST LESS AND LAST LONGER.

THIS

NOT THIS

LITTLE SHEAVES
AND A BIG PULL
AREN'T AS GOOD
AS BIG SHEAVES
AND A
LITTLE PULL!

BELTS MUST BE MATCHED

Matched belts run smoother, look better, last longer.

SAVE OLD BELTS

Old belts can be rematched for emergency use.

BELT IDLERS ARE BELT BREAKERS

Maintain belt tension with motor adjustment instead of using belt-breaking idlers.

USE MOTORS WITH ADJUSTABLE BASES

Move motor toward driven machine so belts go on easily.

NEVER force belts over sheaves. It breaks them.

Move motor back and tighten down with no slack in belts.

STRAIGHT BELTS LAST LONGER

Recheck drives after installation for alignment.

Both sheaves must have corresponding grooves in alignment.

Driving and Driven shafts must be parallel.

USE ENOUGH BELTS ON EVERY DRIVE

YOU WOULDN'T DO THIS

A one-ton truck is sure to break down with a two-ton load.

THEN DON'T DO THIS

Overloads ruin belts too! If 10 belts give Normal Life 12 belts will give Double Life and 8 belts give only 40% Life.

Fig. 9.38 Use of belts
(Courtesy of Browning)

After a few days of operation, the belts will seat themselves in the sheave grooves. Readjust the belts so that the belt drive again shows a slight bow in the slack side.

The belt drive is now properly tensioned and only occasional readjustment for groove wear will be necessary. If belts squeal during startup, reposition motor to increase tension unti slippage and squeal disappear.

If belts are adjusted too tightly, problems can result such as bearing heating and belts wearing excessively.

Always be sure that belt guards are in place and covering all exposed portions of belts whenever the equipment is operating.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 231.

9.56F What is an advantage of driving a pump with belts?

9.56G Why must all belts on a pump be replaced at the same time?

9.56H Why should belts and sheaves be kept clean?

9.56I How can you determine if motor and pump sheave are properly aligned?

9.56J How can you determine if a belt has the proper tightness or tension?

9.56K What should you do when belts squeal during start up?

9.56L What happens when belts are adjusted too tight?

9.564 Flexible Shafting

Flexible shafting is used where the pump and driver are located relatively far apart (Fig. 9.40). Flexible shafting is particularly suited to transmit power into areas where moisture, dust, corrosive or explosive conditions, or flooding would adversely affect the driving machinery.

Pumping installations with flexible shafting usually have a vertical shaft with the motor located on the floor above the pump. There can be one, two, three, or even more sections of shafting, depending upon the distance between the pump and motor. If there is more than one section of shafting, there will be steady bearing supports.

Shafting is usually trouble-free if installed and lubricated properly. The universal joints (Fig. 9.40) are very similar to those used in your automobile. Universal joints are used to take up any misalignment between pump and driver. The driver and pump need not line up axially, but they must be parallel to one another within plus or minus one degree. Shafts can be offset slightly, but the offset is not necessary. Some manufacturers require and specify a definite offset in some installations. The yokes in the shafting must be in line; that is, the driver and driven yoke must be on the same plane so the two center yokes will be in line.

Lubrication of the universal joints is very important. These should be lubricated every 500 hours of intermittent service, and every 200 hours of continuous service. The particular manufacturer's literature will give the type of lubricant to be used.

Never disassemble the needle bearings from their yokes unless it is necessary to replace the cross and bearing set. To inspect, remove the shaft and test bearings by moving the yoke in all directions to roll the needles. If the action of all four bearings is smooth, replacement is not necessary. If the action is rough or uneven, replace the entire universal joint. A visual inspection will usually tell if one bearing is bad by the appearance of a brown powder in that area. When greasing, if grease does not come out all four bearings, you can usually be assured of a bearing failure. Other clues that may indicate a failing U-joint (universal joint) include (1) any play or detectable motion in U-joint when shafting is rocked back and forth (with unit off, but still coupled), and (2) unusual noises while equipment is operating.

To replace bearings, have a skilled operator do this job. Tap one end of bearing lightly to remove pressure on the snap ring. Remove the snap ring, and repeat procedure for the opposite bearing. Then with a soft drift, drive on one bearing to push the opposite bearing out of its yoke. Remove exposed bearing and reverse joint and drive on the exposed cross to push out the other bearing. Repeat procedure on other two bearings.

To assemble, remove bearings from the new cross assembly, holding the cups so the needles do not fall out. Position the cross in one yoke. Position one bearing cup with its needles in the yoke and insert the journal of the cross into this bearing. Press bearing into yoke. Repeat for opposite bearing. If press is not available, use a vise. Never hammer new bearings. Install snap rings, and repeat for other two bearings.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 231.

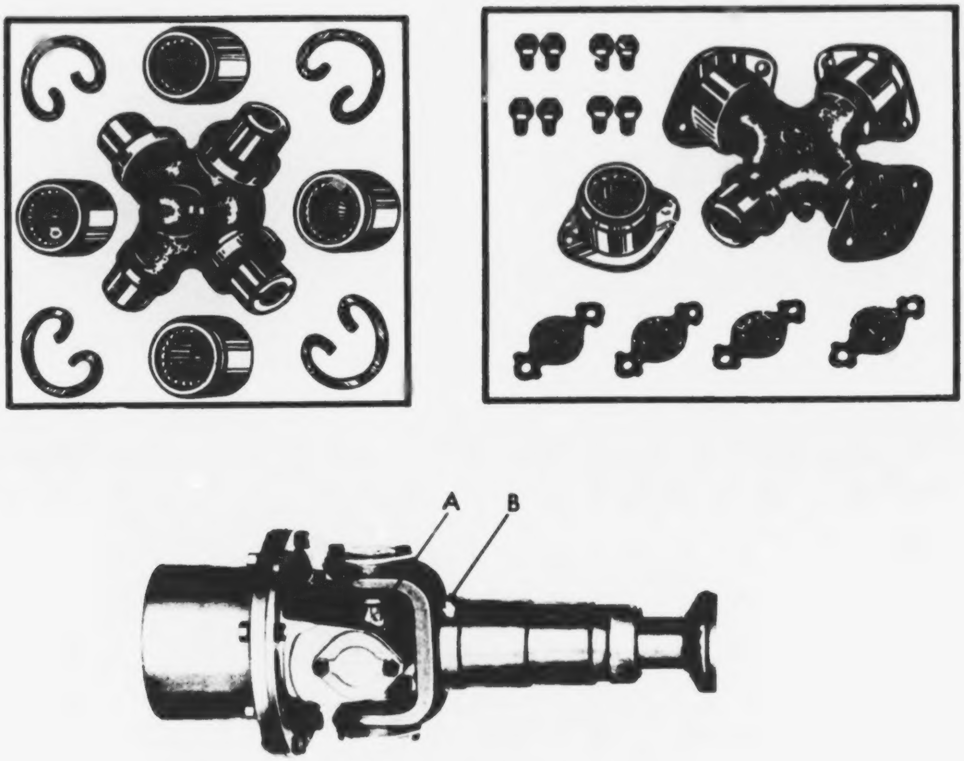
9.56M When is flexible shafting installed?

9.56N How often should universal joints be lubricated?

9.56O How can you tell if there is a bearing failure in a universal joint?

END OF
LESSON
3 OF 4
LESSONS
ON

EQUIPMENT MAINTENANCE



DRIVER & DRIVEN SHAFTS MUST BE PARALLEL
and YOKES MUST BE IN LINE

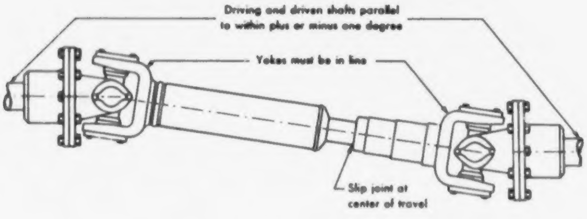

Driving and driven shafts parallel to within plus or minus one degree
Yokes must be in line
Slip joint at center of travel

Fig. 9.40 Flexible shafting and universal joints
(Courtesy of H.S. Watson Company)

DISCUSSION AND REVIEW QUESTIONS

Chapter 9. EQUIPMENT MAINTENANCE

(Lesson 3 of 4 Lessons)

Write the answers to these questions in your notebook before continuing. The problem numbering continues from Lesson 2.

13. What would you look for when inspecting a pump impeller?
14. What factors can cause cavitation of a pump impeller?
15. How would you inspect a pump shaft?
16. How would you repack a pump?
17. What are the advantages and limitations of mechanical seals?
18. What are some causes of bearing failures?
19. How are pumps and drivers connected together?

HOW?
WHAT?
WHEN?
WHERE?
WHO?

CHAPTER 9. EQUIPMENT MAINTENANCE

(Lesson 4 of 4 Lessons)

9.6 COMPRESSORS

Compressors (Figure 9.41) are commonly used in the operation and maintenance of wastewater collection systems. They are used to activate wastewater ejectors, pump control systems (bubblers), valve operators, and water pressure systems. They are also used to operate portable pneumatic tools such as jack hammers, compactors, air drills, sand blasters, tapping machines, and air pumps.

A compressor is a device used to increase the pressure of air or gas. They can be of a very simple diaphragm or bellows type such as are found in aquarium pumps, or extremely complex rotary, piston, or sliding-vane type compressors. A compressor usually has a suction pipe with a filter and a discharge pipe which goes to an air receiver or storage tank. The compressed air or gas is then used from the air receiver.

Due to the complexity of compressors, the wastewater maintenance operator usually will not be repairing them. You will, however, be required to maintain these compressors. With proper maintenance a compressor should give years of trouble-free service.

The first step for compressor maintenance, and this pertains to any mechanical equipment, is to get the manufacturer's instruction book and read it completely. Each compressor is different and the particular manufacturer will list their recommended maintenance schedules and procedures. Some of the maintenance procedures are discussed in the following paragraphs.

MFG'RS INSTRUCTION BOOK

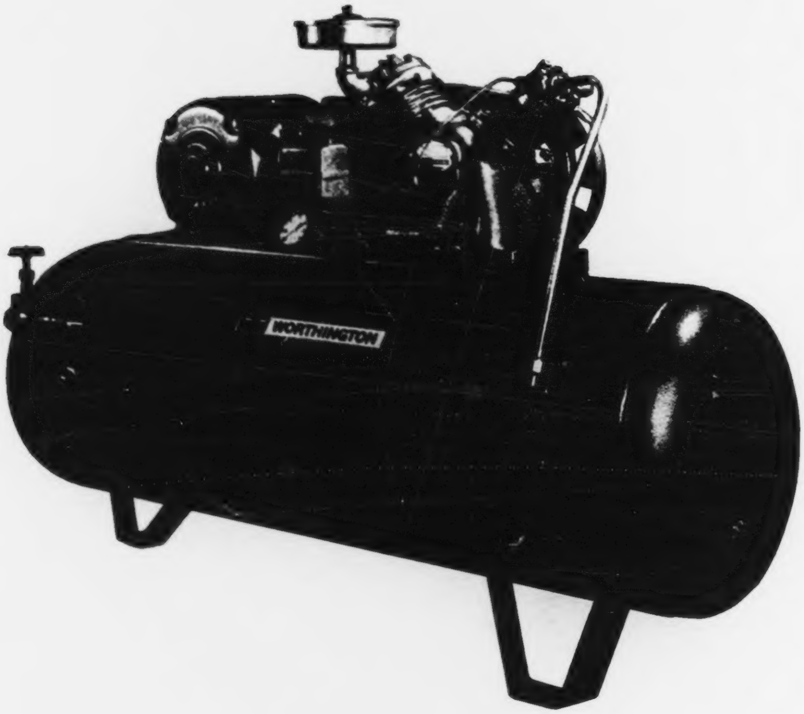
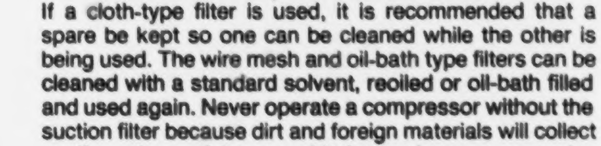


Fig. 9.41 Two-stage piston compressor
(Courtesy Worthington Corporation)

1. Inspect the suction filter of the compressor regularly. The frequency of cleaning depends upon the use of the compressor and the atmosphere around it. Under normal operations the filter should be inspected at least monthly and cleaned or replaced every three to six months. Inspect and replace the filter more frequently in areas with excavation and dust. When breaking up concrete, inspect the filters daily.



There are several types of filters, such as paper, cloth, wire screen, oil bath, and others. The impregnated paper filters must be replaced when dirty. The cloth-type filters can be washed with soap and water, dried and reinstalled. If a cloth-type filter is used, it is recommended that a spare be kept so one can be cleaned while the other is being used. The wire mesh and oil-bath type filters can be cleaned with a standard solvent, reoiled or oil-bath filled and used again. Never operate a compressor without the suction filter because dirt and foreign materials will collect on the rotors, pistons, or blades and cause excessive wear.

2. Lubrication. Improper or lack of lubrication is probably the biggest cause of compressor failures. Most compressors require oiling of the bearings. They can have crank case reservoirs, oil cups, grease fittings, a pressure system or separate pump. Whatever type, it must be inspected daily. Examine the reservoir dip stick or sight glass. Make sure that drip-feed oilers are dripping at the proper rate; force-feed oilers have the proper pressure; and grease fittings are greased at the proper interval. Compressors use a certain amount of oil in their operation and special attention is needed to keep the reservoirs full. Care also must be used to not overfill the crankcase. On some compressors it is possible for the oil to get into the compression side and lock up the compressor, or damage it. Remember!

A LIQUID CANNOT BE COMPRESSED.

When air or gas are compressed, they give off heat and the compressor becomes very hot. This tends to break down oil faster, so most compressor manufacturers have special oils recommended for their particular compressor. Also, due to the heat and contamination, it is necessary to change oil quite frequently. Compressor oil should be changed at least every three months, unless manufacturer states differently. If there are filters in the oil system, these also should be changed.

3. Cylinder or casing fins should be cleaned weekly with compressed air or vacuumed off. The fins must be clean to insure proper cooling of the compressor.

4. Unloader. Many compressors have unloaders that allow the compressor to start under a no-load condition. These can be inspected by observing the compressor. When the compressor starts, it should come up to speed and the unloader will change, starting the compression cycle. This can usually be heard by a change in sound. When it stops, you can hear a small pop and hear the air bleed off the cylinders. If the unloader is not working properly, the compressor will stall when starting, not start, or if belt-driven, burn off the belts.

5. Test the safety valves weekly. The pop off or safety valves are located on the air receiver or storage tank. They prevent the pressure from building up above a specified pressure by opening and venting to the atmosphere. In gas compressors, they vent to the suction side of the compressor. Some compressors have high pressure cut-off switches, low oil pressure switches, and high temperature cut-off switches. These switches have preset cut-off settings and must not be changed without proper authorization. If for any reason any of the safety switches are not functioning properly, the problem must be corrected before starting the compressor again. The safety switch settings should be recorded and the results kept in the equipment file.

6. Drain the condensate (condensed water) from the air receiver daily. Due to temperature changes, the air receiver will fill with condensate. Each day the condensate should be drained from the bottom of the tank. There is usually a small valve at the bottom of the air receiver for this purpose. Some air receivers are equipped with automatic drain valves. These must be inspected periodically to insure they are operating satisfactorily.

7. Inspect belt tension on compressors. Usually you should be able to press the belt down with hand pressure approximately three-fourths of an inch. This is done at the center between the two pulleys. MAKE SURE COMPRESSOR IS LOCKED OFF BEFORE MAKING THIS TEST. Do not over-tighten belts because it will cause overheating and excessive wear on bearings and motor overloading.

8. Examine operating controls. Make sure the compressor is starting and stopping at the proper settings. If it is a dual installation, make sure they are alternating if so designed. Inspect gage for accuracy. Compare readings with recorded startup values or other known, accurate readings.

9. Many portable compressors are equipped with tool oilers on the receivers. These are used for mixing a small quantity of oil with the compressed air for lubrication of the tools being used. These are located on the discharge side of the air receiver. They have a reservoir which must be filled with rock drill oil.

10. All compressors should be thoroughly cleaned at least monthly. Dirt, oil, grease, and other material must be thoroughly cleaned off the compressor and surrounding area. Compressors have a tendency to lose oil around piping, fittings and shafts; thus constant cleaning is required by the maintenance operator to insure proper and safe operation.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 231.

9.6A List some of the uses of a compressor in connection with operation and maintenance of a wastewater collection system.

9.6B How often should the suction filter of a compressor be cleaned?

9.6C How often should compressor oil be changed?

9.6D How often should the condensate from the air receiver be drained?

9.6E What must be done before testing belt tension on compressors with your hands?

9.7 LUBRICATION

9.71 Purpose of Lubrication

Lubrication of equipment is probably one of the most important phases of a maintenance operator's job. Without proper lubrication the tools and equipment used for operating and maintaining wastewater collection systems would fail. Proper lubrication of tools and equipment is probably one of the maintenance operator's easiest jobs, but often it is the most neglected.

The purpose of lubrication is to reduce friction between two surfaces. Lubrication also removes heat that is caused by friction. Solid friction of two dry surfaces in contact is changed to a fluid friction of a separating layer of liquid or liquid lubricant. Actually water is a lubricant, although not a good lubricant.

9.72 Properties of Lubricants

A good lubricant must have the following properties:

1. Form a slippery coating on contacting surfaces so they can slide freely past each other, and
2. Exert sufficient pressure to keep the surfaces apart when running.

To be a good lubricant for a particular job, the lubricant used must have the following qualities:

1. Thickness of the lubricant layer must be sufficient to keep the roughness of the metal parts from touching.
2. Lubricity (slipperiness) must be sufficient to allow molecules to slide freely past each other, and
3. Viscosity (resistance to flow) must be sufficient to build up a pressure necessary to keep the surfaces apart. If viscosity alone cannot provide enough pressure, an external pressure must be supplied by a pump.

Viscosity in the United States is the number of seconds it takes 60 cubic centimeters (cc) of an oil to flow through the standard orifice of a Saybolt Universal Viscometer at 100, 130, or 210 degrees Fahrenheit. A 300 - *SSU*[9] @ 130 oil means that it took 300 seconds for 60 cc to flow through a Saybolt Universal Viscometer at 130 degrees Fahrenheit. Viscosity decreases with temperature rise because oil becomes thinner. The specific gravity of an oil is measured by comparing the weight of oil with an equal volume of water, both at 60 degrees Fahrenheit.

Some other important information to know about lubricants is their "Pour Point," "Flash Point," and "Fire Point." "Pour Point" is the temperature at which a lubricant refuses to run. This is important in low temperature work. "Flash Point" is the temperature at which oil vaporizes enough to ignite momentarily when near a flame. A low flash point means that oil evaporates more readily in service. "Fire Point" is the temperature at which oil vaporizes enough to keep on burning. Oils in service tend to become acid and may cause corrosion, deposits, sludging and other problems. This condition may not be visible when you look at the oil. Therefore, do not extend the time for an oil change because the oil looks clean.

To detect acid conditions in oils, the neutralization number of an oil is used. The neutralization number is the weight in milligrams of potassium hydroxide required to neutralize one gram of oil. This is used by laboratories which test the oil on large engines, turbines, compressors, and other equipment which have large volume oil reservoirs to determine when oil changes or additives are needed.

Most lubricants in general use are fluid at room temperature. Mostly, these are petroleum base, but others are used. Greases are mixtures of petroleum products with soaps such as lime, soda, aluminum, and metallic. Metallic soaps, forms of calcium, sodium, potassium, and lithium, have good retention in bearings and can withstand high temperatures and pressures. A sodium-base grease has sodium as the soap mixed with the petroleum.

Solid materials such as graphite, finely ground mica, asbestos, and yarn are sometimes used as lubricants. Some recently developed silicon compounds (silicones) work very well under heavy loads and widely varying temperatures.

There are many oil additives on the market today and they are worth investigating. Oil additives are chemical compounds added to an oil to improve certain chemical or physical properties such as stability, lubricity and foaming. They are used to prevent rust or deposits and many other items that could cause problems.

9.73 Lubrication Schedule

To have proper lubrication you must first set up a lubrication schedule. This can be a simple check-off sheet or card system or an elaborate computer system. The first thing to do is make a list of everything that needs lubrication down to the smallest item, including chains, rollers, and sprockets. After you have listed every item on paper, go through the manufacturer's instruction books to determine the frequency and type of lubrication required. Is the frequency daily, weekly, monthly, semi-annually, or annually? The manufacturer's literature usually lists several different name brands of lubricants which are equal. If you need help determining the type of lubricant or cross referencing it to your particular brand, contact your supplier. Most oil distributors have a service representative who will come to your facility and go over the individual equipment and specify which lubricants you should use. Next, determine the amount of each lubricant required. This is achieved by counting the number of grease fittings. Determine the locations of fill plugs, drain plugs, oil levels, sight glasses, dip sticks and other important items. To find these locations, physically inspect each piece of equipment thoroughly and look for all lubrication points. Also the manufacturer's maintenance manual should show the lubrication points for each piece of equipment.

When you have gathered all this information, transfer it to the equipment history cards or computer history data files for future reference. From this information you can make up a lubrication chart (Fig. 9.42).

As stated earlier, use whatever type of lubrication form you prepare, but follow it. Always record each lubrication job when completed and have the operator who did the job initial the record card. Always keep your lubrication schedules up to date. If there are failures due to the wrong or insufficent lubricant, change or increase the lubrication frequency on the schedule. Also, new equipment must be added and discarded equipment removed from the schedule. Someone must be assigned to take care of the lubrication and records. Assign more than one operator or rotate this job so if an individual is off work or leaves the crew, there is a continuity in the lubrication schedule.

9.74 Precautions

When handling or storing oils and greases, some special precautions must be followed. Make sure the storage area does not create a fire hazard. Most all lubricants are highly flammable and shouldn't be stored where there is an open flame. "NO SMOKING" signs must be posted outside the building. Be sure to keep any spills wiped up and make sure that all the lids are tight on their containers.

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[9] *SSU. Standard Saybolt Units.*

Balling Rig #2

Item	Lubricant	Change
Motor.	Heavy Duty #30	**Quarterly**
Brakes.	Brake Fluid #500	Monthly (check)
Universals.	Grease. F-2	Monthly.
Air Cleaner Bath.	SAE #20	Quarterly
Wheel Bearings.	Grease. Wheel Type	Semi-annual
Power Steering.	Red Line ATF #30	Quarterly (check).
Transmission.	Red Line ATF #30	Quarterly (check).
Aux. Engine on Rear.	H.D. #30	Weekly.
Gear Box on Reel.	Worm Gear. #90	Quarterly.
Cable Spool.	Grease. F-2	Daily.
Sheave on Level Wind.	Grease. F-2	Daily.
Upper Bearings on Level Wind.	Oil. #20	Weekly.
Chain Drive.	Oil. #10	Monthly.

Fig. 9.42 Lubrication Chart

When storing lubricants, cleanliness is of utmost importance. A grease pail or oil drum which has become contaminated with dirt, water, or other material should be discarded. Contaminated lubricants will ruin the equipment you are trying to protect. Try using grease cartridges instead of grease pails because they are easier to keep clean and store. Grease cartridges are easy to load in the grease gun and can be discarded when empty. They cost a little more initially, but the savings in handling and a reduction in the chance of contamination may make them cheaper in the long run.

Proper equipment lubrication requires very special care when installing lubricants.

GREASING

1. Shut off, lock out, and tag unit being greased so you won't be injured if the equipment should start unexpectedly.
2. Use the proper grease.
3. Make sure grease is clean and free of dirt.
4. Pump a small amount of grease into a rag and wipe off end of grease gun.
5. Clean grease fitting to be greased with a clean rag. If a plug is to be removed, clean area around plug before removing plug and inserting grease fitting.
6. Remove any relief plug before pumping in grease.
7. Pump in the proper amount of grease as indicated on the equipment card.
8. Wipe off all excessive grease around unit.
9. Clean vent before replacing vent plug to allow for expansion of grease and to allow excess grease to work out of bearing.
10. Replace vent plugs. Do not completely fill a grease cavity and tighten vent plugs on cold grease. Leave one vent plug loose and run equipment to force excess grease out during warm-up. After warm-up, tighten last vent plug.
11. Record the date and your initials on the lubrication record.
12. Record and describe any unusual conditions.

OILING

1. Make sure that the equipment being serviced is shut off, locked out and tagged out of service so you won't be injured if the equipment should start unexpectedly.
2. Check to make sure oil is the proper type and grade, as indicated on the equipment record card.
3. Wipe area around fill and drain plugs with clean rag. Also, wipe off top of oil can and cap.
4. Place container under drain plug and remove it along with the fill plug.
5. Make sure all the oil is drained out and reinstall drain plug or plugs.
6. Pour in new oil. If a funnel or spout is used, be sure to wipe it clean before starting. Fill to proper level in sight glass or dip stick. Do not overfill.
7. Install fill plug or plugs and wipe up any excess or spilled oil.
8. After equipment has been started, observe oil level to make sure it is at proper level.
9. Record the date, lubricant, and your initials on the lubrication record.
10. Record and describe any unusual conditions.
11. Place all caps on oil containers and return them to their storage place along with the funnels, pumps, and whatever else was used.

9.75 Final Cleanup and Inspection

When lubrication is completed, make sure all oily rags and materials are placed in a covered metal can while waiting to be picked up or disposed of. If it is necessary to transfer oil to different cans, make sure they are labeled properly. Never leave an open oil can laying around to use when the unit needs more oil.

After your lubrication is completed, inspect the equipment in a few hours to make sure it is not overheating or making any strange or unusual noise. Examine the oil levels to make sure they are at their proper level. Proper lubrication is the key to successful equipment maintenance.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 231.

9.7A What is the purpose of lubrication?

9.7B What happens to oils in service?

9.7C What should be done to insure proper lubrication of equipment?

9.7D What should be done when lubrication failures occur?

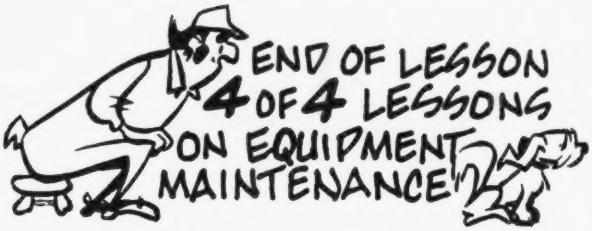
9.7E What precautions must be taken when handling or storing oils and greases?

9.7F What precautions must be taken before oiling or greasing equipment?

9.7G What should be done after lubrication job is completed?

9.8 ADDITIONAL READING

1. *MAINTENANCE ENGINEERING HANDBOOK,* by Higgins, McGraw-Hill Book Company, PO Box 402, Hightstown, New Jersey 08520. Price $82.50.
2. *PUMP HANDBOOK,* Second Edition, edited by Egor J. Karassik, William C. Krutzsch, Warren H. Fraser and Joseph P. Messina, McGraw-Hill Book Company, 1221 Avenue of the Americas, New York, NY, 10020, price, $84.50.
3. *NATIONAL ELECTRICAL CODE HANDBOOK,* Joseph F. McPartland, 19th Edition (Based on the current 1987 National Electrical Code). McGraw-Hill Book Company, 4th Floor, 11 W. 19th Street, New York, NY 10011, Attention: Professional and Reference Division, price $42.50.
4. *MOTOR AND GENERATOR STANDARDS PUBLICATION* #MG1-1987. Available from National Electrical Manufacturers Association (NEMA), 2101 L Street, NW, Suite 300, Washington, DC 20037.



DISCUSSION AND REVIEW QUESTIONS

Chapter 9. EQUIPMENT MAINTENANCE

(Lesson 4 of 4 Lessons)

Write the answers to these questions in your notebook before continuing to the objective test on page 232. The problem numbering continues from Lesson 3.

20. What are the uses of a compressor?
21. What items should be maintained on a compressor?
22. How would you develop a lubrication schedule for a pump?
23. Why is cleanliness important in the storing and use of lubricants?
24. How would you clean up after a lubrication job is completed?

SUGGESTED ANSWERS

Chapter 9. EQUIPMENT MAINTENANCE

ANSWERS TO QUESTIONS IN LESSON 1

Answers to questions on page 129.

9.1A Unqualified or inexperienced people must be extremely careful when attempting to troubleshoot or repair electrical equipment because they can be seriously injured and damage costly equipment if a mistake is made.

9.1B When machinery is not shut off, locked out, and tagged properly, the following accidents could occur:

1. Maintenance operator could be clearing pump and have it start, thus losing an arm, hand, or finger,
2. Electrical motors or controls not properly grounded could lead to possible severe shock, paralysis, or death, and
3. Improper circuit — wrong connection, safety devices jumped, wrong fuses, or improper wire. These mistakes can cause fires, or injuries due to incorrect operation of machinery.

Answers to questions on page 132.

9.22A The two types of voltage are Direct Current (D.C.) and Alternating Current (A.C.).

9.22B Amperage is a measurement of work being done or "how hard the electricity is working."

9.22C The proper voltage and allowable current in amps for a piece of equipment can be determined by reading the nameplate information or the instruction manual for the equipment.

Answers to questions on page 135.

9.23A You test for voltage by using a voltage tester.

9.23B A voltage tester can be used to test for voltage, open circuits, blown fuses, single phasing of motors and grounds.

9.23C Before attempting to change fuses, turn off power and check both power lines for voltage. Use a fuse puller.

9.23D If the voltage is unknown and the voltmeter has different scales that are manually set, always start with the highest voltage range and work down. Otherwise the voltmeter could be damaged.

9.23E Amp readings different from the nameplate rating could be caused by low voltage, bad bearings, poor connections, plugging or excessive load.

9.23F Motors and wirings should be megged at least once a year, and twice a year if possible.

9.23G An ohmmeter is used to test the control circuit components such as coils, fuses, relays, resistors and switches.

Answers to questions on page 139.

9.24A The two types of safety devices in main electrical panels or control units are fuses or circuit breakers.

9.24B Fuses are used to protect operators, wiring, circuits, heaters, motors, and various other electrical equipment.

9.24C A fuse must never be by-passed or jumped because the fuse is the only protection the circuit has. Without it, serious damage to equipment and possible injury to operators can occur.

9.24D A circuit breaker is a switch that is opened automatically when the current or the voltage exceeds or falls below a certain limit. Unlike a fuse that has to be replaced each time it "blows," a circuit breaker can be reset after a short delay to allow time for cooling.

9.24E The most common pump driver used in lift stations is the AC induction motor.

9.24F Types of lift station failures that can occur due to lack of proper maintenance include:

1. Current imbalances which ultimately result in motor failure,
2. Loose contacts or terminals in control and power circuits causing high resistance contacts,
3. Overheating resulting in arcing, fire, and electrical system damage,
4. Dirty enclosures and components which allow a conductive path to build up between incoming phases causing phase-to-phase shorts, and
5. Corrosion causing high resistance contacts and heating.

9.24G If a fuse or circuit breaker "blows" or trips, the potential source of the problem should be investigated, identified and corrected.

9.24H Annual maintenance that should be performed with regard to fuses includes:

1. Inspect all bolted connections at the fuse clip or fuse holder for signs of looseness,
2. Check connections for any evidence of corrosion from moisture or atmosphere (air pollution),
3. Tighten connections,
4. Check fuse for obvious overheating,
5. Inspect insulation on the conductors coming into the fuses on the line side and out of the fuses on the load side for evidence of discoloration or bubbling which would indicate overheating of the conductors.

Answers to questions on page 140.

9.25A The motor and supervisory control systems are composed of the auxiliary electrical equipment such as relays, transformers, lighting panels, pump control logic, alarms, and other electrical equipment typically found in a lift station electrical system.

9.25B The three basic factors that contribute to the reliable operation of electrical systems found in lift stations include:

1. An adequate preventive maintenance program must be implemented,
2. A knowledge of the system by the collection system operator, even though the operator does not perform the actual maintenance, and
3. KEEP IT CLEAN! KEEP IT DRY! KEEP IT TIGHT!

Answers to questions on page 153.

9.3A The two types of induction motor construction which are typically encountered when dealing with AC induction motors are:

1. Squirrel cage induction motor and
2. Wound rotor induction motor.

9.3B The five most common causes of electric motor failure are (1) overload (thermal), (2) single phasing, (3) contaminants, (4) old age, and (5) bearing failures.

9.3C The three components of an insulation temperature rating consist of:

1. Ambient operation temperature,
2. Temperature rise, and
3. Hot-spot allowance.

9.3D The direction of rotation of a three-phase motor can be changed by changing any two of the power leads.

9.3E Motor starters can be either manually or automatically controlled.

9.3F Magnetic starters are usually used to start pumps, compressors, blowers and anything where automatic or remote control is desired.

9.3G The two types of overload protection devices used with magnetic starters are:

1. A bimetallic strip which is precisely calibrated to open under higher temperature conditions to de-energize the coil, and
2. A small solder pot within the coil that melts because of the heat and will de-energize the system.

Answers to questions on page 159.

9.3H The key to effective troubleshooting is practical, step-by-step procedures combined with a common sense approach.

9.3I When troubleshooting:

A. Gather preliminary information.

B. Inspect:

1. Contacts.
2. Mechanical parts, and
3. Magnetic parts.

9.3J Types of information that should be recorded regarding electrical equipment includes every

1. Change,
2. Repair, and
3. Test.

ANSWERS TO QUESTIONS IN LESSON 2

Answers to questions on page 168.

9.41A Pumps are used to move or lift wastewater in collection systems and treatment plants. They also are used to pump water in high velocity cleaners and to dewater construction projects. In addition, backhoes have hydraulic pumps and automobiles have oil and water pumps.

9.41B If we know how a pump is built, it is easier to understand how to operate and maintain a pump.

9.41C Pump lubricants should be changed in accordance with the pump manufacturer's lubrication instructions. If the instructions are not available or if in doubt, call the supplier for recommendations. Play it safe and change the lubricant *BEFORE* it's too worn or too dirty. Look at the lubricant after the pump has run at equilibrium temperature. Any used oil or oil needing change will become discolored and turn grey or black.

9.41D A pump is in proper alignment if the pump and motor flanges are parallel vertically and axially — and *KEPT* that way.

9.41E Horizontal suction lift piping must always slope upward towards the pump to prevent air pockets and loss of suction.

9.41F Piping can be kept from straining the pump casing by (1) being properly supported, and (2) regular inspection to be sure the pump or piping has not shifted or settled and caused a strain. Look for evidence of a heavy object in contact with the piping that could have caused misalignment and/or a strain.

9.41G A pump should never be allowed to run dry because water acts as a lubricant between the wearing rings and the impeller.

Answers to questions on page 178.

9.42A Three types of centrifugal pumps include (1) horizontal non-clog, (2) vertical ball-bearing, and (3) propeller.

9.42B Screw pumps consist of a screw operating at a constant speed within a housing or trough. The screw has a pitch and is set at a specific angle. When revolving, the screw conveys the wastewater up the trough to a discharge point.

9.42C Pneumatic ejectors are used when it is necessary to handle limited or low flows with relatively large solids.

9.42D Piston pumps are commonly used in high velocity cleaners.

Answers to questions on page 182.

9.42E Portable centrifugal pumps are often referred to as trash pumps because the water being pumped is not clean and may have solids of various sizes suspended in the water.

9.42F The suction hose has a strainer on the end to prevent pulling rocks and debris into the pump to avoid damaging the pump or plugging the hoses or pipes.

9.42G When operating a portable pump in weather that is subject to freezing, always drain the pump to prevent the freezing water from cracking the casing or binding up the pump. Before starting the pump, turn the shaft by hand to be sure it turns freely. If the impeller is frozen fast, warm the pump slowly until the ice melts.

Answers to questions on page 185.

9.42H Some of the advantages of the positive displacement diaphragm pump are as follows:

1. Self-priming if the suction lift is small,
2. When primed with water, it will pump with a suction lift up to 25 feet,
3. Large particles will readily pass through the pumps, and
4. Less likely to become clogged than centrifugal pumps.

9.42I If a diaphragm pump suddenly stops pumping, remove discharge valve and clean out pump cavity.

9.42J After use, pneumatically operated diaphragm pumps should be flushed thoroughly to prevent dried sediment from obstructing valve operation. If the water pumped had large particles in it, it may be necessary to dismantle the pump to remove any remaining particles.

ANSWERS TO QUESTIONS IN LESSON 3

Answers to questions on page 189.

9.51A Impellers should be inspected on a regular basis such as every 6 months or annually, depending on pumping conditions. If grit, sand, or other abrasive type of material is being pumped, inspections should be more frequent.

9.51B Wearing rings protect the impeller and pump body from damage due to excessive wear.

9.51C If pump clearances are not kept in proper adjustment, the pump may become plugged frequently and power requirements will increase due to lowered efficiency.

9.51D An impeller shows cavitation damage if it has pits on the surface.

9.51E Cavitation can be caused by a pump operating under different conditions than what it was designed for, such as, off the design curve, poor suction conditions, high speed, air leaks into suction end and water hammer conditions.

Answers to questions on page 191.

9.52A Pump shafts can be protected from damage by the installation of shaft sleeves over the shaft in the area on the shaft where it passes through the stuffing box.

9.52B A pump shaft sleeve must be replaced when grooves are observed.

Answers to questions on page 195.

9.53A Packing is used to keep water from leaking out where the shaft passes through the casing.

9.53B The lantern ring is used to allow outside water or grease to enter the packing for lubrication, flushing, and cooling.

Answers to questions on page 197.

9.54A A pump with a mechanical seal (or any other type of seal) should never be run dry because water is required for seal lubrication.

9.54B Mechanical seals are not supposed to have any leakage from the gland; and if a leak develops, the seal may require relapping or it may have to be replaced.

Answers to questions on page 216.

9.55A The different types of bearings used in pumps include ball bearings, roller bearings, and sleeve bearings.

9.55B Whenever a bearing failure occurs before its expected replacement time, the bearing should be examined to determine the cause, and if possible, to eliminate the problem.

9.55C The different types of bearing failures include fatigue failure, contamination, brinelling, false brinelling, thrust failures, misalignment, electric arcing, lubrication failure, and cam failure.

9.55D Contamination failure of a bearing can be caused by dirty or damp surroundings or abrasive waste materials. Contamination failure can be prevented by removing the source of contamination.

9.55E Bearing failures from misalignment can be prevented by insuring proper alignment of pump shaft and housing.

9.55F Bearing lubrication failures can be identified by grease appearance, abnormal temperature rise, noise, bearing discoloration, and retainer failure.

Answers to questions on page 218.

9.56A Couplings are used to connect a source of power to the shaft, such as the shaft of a pump impeller.

9.56B Methods by which a pump and driver can be coupled together include direct coupled, belt-driven, flexible shafting and closed-coupled.

9.56C The functions of a flexible coupling include transmitting power from one shaft to the other, decreasing wear on shaft bearings and driven equipment, accommodating slight shaft misalignments, absorbing shock loads and pulsations, dampening vibrations, accommodating load reversals, minimizing initial backlash, and making assembly and disassembly easy.

9.56D To inspect for proper alignment, look for parallel and angular misalignment using feelers — a straightedge placed squarely across the rings of the coupling halves. Place the feelers at the top, bottom, near and far sides of the coupling junctions. Also place the feelers along the edge of top and sides of the shaft. Dial indicators also may be used.

9.56E When inspecting clearance between faces of coupling halves, be sure they are set so they cannot strike, rub, or exert a pull on either machine.

Answers to questions on page 220.

9.56F An advantage of driving a pump with belts is that different speed ratios can be achieved between the motor and pump. Also the motor can be placed in a variety of positions with respect to the pump.

9.56G All belts on a pump must be replaced at the same time with a matched set so all belts will wear evenly.

9.56H Belts and sheaves must be kept clean to reduce wear on both belts and sheaves.

9.56I Alignment of pump and motor sheaves can be determined by (1) placing a straightedge between the two pulleys or (2) pulling a string across both pulleys.

9.56J Proper belt tension is achieved when the belts have only a slight bow on the slack side of the belt drive while operating under load, or when belts have a ¾-inch movement from hand pressure at mid-point of slack belt when unit is off.

9.56K If belts squeal during startup, reposition motor adjustment to increase tension until slippage and squeal disappear.

9.56L When belts are adjusted too tight, problems can result, such as bearings heating and excessive belt wear.

Answers to questions on page 220.

9.56M Flexible shafting is installed when the pump and driver are located relatively far apart.

9.56N Universal joints should be lubricated every 200 hours during continuous service and every 500 hours during intermittent service. Consult manufacturer's literature for type of lubricant and details.

9.56O Failure of a bearing in a universal joint can be indicated if:

1. Grease does not come out all four bearings when greasing,
2. Brown powder appears in the area of one bearing, or
3. Rough, uneven play occurs when the yoke is removed.

Answers to questions on page 224.

9.6A Compressors are used with wastewater ejectors, pump control systems (bubblers), valve operators, and water pressure systems. Also they are used to operate portable pneumatic tools such as jack hammers, compactors, air drills, sand blasters, tapping machines, and air pumps.

9.6B The frequency of cleaning a suction filter on a compressor depends on the use of a compressor and the atmosphere around it. The filter should be inspected at least monthly and cleaned or replaced every three to six months. More frequent inspection, cleaning and replacement are required under dusty conditions such as operating a jack hammer on a street.

9.6C Compressor oil should be changed at least every three months, unless manufacturer states differently. If there are filters in the oil system, these also should be changed.

9.6D Drain the condensate from the air receiver daily.

9.6E Before testing belt tension on a compressor with your hands, *MAKE SURE COMPRESSOR IS LOCKED OFF.*

Answers to questions on page 227.

9.7A The purpose of lubrication is to reduce friction between two surfaces and to remove heat caused by friction.

9.7B Oils in service tend to become acid and may cause corrosion, deposits, sludging and other problems.

9.7C To insure proper lubrication of equipment, determine the proper lubrication schedule, lubricant, and amount of lubricant and prepare a lubrication chart.

9.7D When lubrication failures occur, try to identify cause and change lubricant and/or frequency of lubrication if necessary.

9.7E Oils and greases can create a fire hazard. All spills must be wiped up immediately. Oils and greases must not become contaminated with dirt, water or other material.

9.7F Before oiling or greasing equipment, shut it off, lock it out and tag it so it won't start unexpectedly and injure you.

9.7G After lubrication job is completed, clean up area, properly store or dispose of oil rags and materials, and inspect lubricated equipment in a few hours to make sure it is not overheating or making any strange or unusual noises.

OBJECTIVE TEST

Chapter 9. EQUIPMENT MAINTENANCE

Please mark correct answers on answer sheet as directed at end of Chapter 1. There may be more than one correct answer to each question.

TRUE-FALSE

1. Effective equipment and sewer maintenance is the key to successful system performance.
   1. True
   2. False

2. When a pump is not shut off, locked out, and tagged properly, a maintenance operator could be cleaning a pump, the pump could start, and the operator could lose a finger.
   1. True
   2. False

3. Most electrical equipment does not contain the proper voltage on the nameplate.
   1. True
   2. False

4. Closing an electrical circuit is like closing a valve on a water pipe.
   1. True
   2. False

5. Long pump suction lines should be used to reduce pipe friction losses.
   1. True
   2. False

MULTIPLE CHOICE

6. Which of the following items are parts of an electric motor?
   1. Impeller
   2. Rotor
   3. Stator
   4. Volute
   5. Windings

7. Centrifugal pump parts include
   1. Diaphragm.
   2. Impeller.
   3. Piston.
   4. Rotor.
   5. Volute.

8. Before inspecting an impeller you should
   1. Close suction and discharge valves.
   2. Drain pump with bolts still in handhole cover until water flow stops.
   3. Open handhole covers and visually inspect for foreign objects which may injure you.
   4. Tag control panel.
   5. Turn off and lock out all electrical power to pump.

9. Which of the following types of pumps are commonly encountered by collection system operators on the job?
   1. Centrifugal pumps
   2. Diaphragm pumps
   3. Rotary pumps
   4. Screw pumps
   5. Submersible pumps

10. Types of bearing failures include
    1. Balling.
    2. Contamination.
    3. Fatigue.
    4. Insufficient loading.
    5. Misalignment.

11. Grooves can be cut into pump shafts by
    1. Dirty seal flushing water.
    2. Glazed packing.
    3. Motor rotor rubbing on stator.
    4. Razor blades.
    5. Wrong type of packing.

12. When inspecting a pump impeller you should look for
    1. Cavitation marks.
    2. Chips, broken tips, corrosion or unusual wear.
    3. Clearances.
    4. Tightness on shaft.
    5. Water in water seal.

13. Wearing rings are installed in a pump to
    1. Hold the shaft in position.
    2. Keep the impeller in place.
    3. Plug internal water leakage.
    4. Wear instead of impeller.
    5. Wear out the sleeves.

14. What could be the cause of a pump electric motor not starting?
    1. Fuse or circuit breaker out
    2. Incorrect power supply
    3. No power supply
    4. Pump not hooked to motor
    5. Rotating parts of motor may be jammed mechanically

15. A voltage tester is used to test for
    1. A.C. or D.C.
    2. Amps.
    3. Blown fuses.
    4. Intensity of voltage.
    5. Watts.

16. Who is qualified to work in an electrical panel?
    1. Crew Leader
    2. Electrician
    3. Maintenance Man I
    4. Maintenance Man II
    5. Supervisor

17. **Equipment nameplate data must be recorded and filed because the**
    1. Filing cabinet is supposed to have this information.
    2. Information is needed to order replacement parts.
    3. Manufacturer doesn't keep the information.
    4. Nameplate could become corroded.
    5. Nameplate could get lost.

18. If packing is not maintained properly, which of the following troubles can arise?
    1. Flooding of pump station
    2. Loss of suction due to air being allowed to enter pump
    3. Must develop a new maintenance schedule
    4. Packing needs less adjustment
    5. Shaft or shaft sleeve damage

19. Compressor maintenance includes
    1. Cleaning cylinder or casing fins weekly.
    2. Examining the oil reservoir dip stick or sight glass.
    3. Inspecting the suction filter of the compressor regularly.
    4. Keeping the belts as tight as possible.
    5. Washing off the compressor weekly.

20. What is the purpose of an equipment preventive maintenance program?
    1. To extend equipment life
    2. To insure proper and efficient operation of the equipment
    3. To keep operators looking at equipment
    4. To protect the public's investment spent buying the equipment
    5. To provide jobs for operators when they visit a facility

21. When belts are used to drive equipment, important considerations include
    1. Belt dressing should be used monthly for pliability of belts.
    2. Belts must be matched sets.
    3. Guards are required on all belt drives that are exposed.
    4. Noise or squeal on startup can be corrected by proper tension.
    5. Proper number of belts.

22. Which of the following precautions must be exercised when handling or storing lubricants?
    1. Do not create a fire hazard
    2. Discard lubricants that become contaminated with water or dirt
    3. Keep lids tight on containers
    4. Post "NO SMOKING" signs on the outside of buildings where lubricants are stored
    5. Wipe up spills

23. The main functions of flexible couplings are to
    1. Accommodate for slight shaft misalignments which develop in service.
    2. Allow shaft to bend.
    3. Decrease wear on shaft bearings.
    4. Keep the shaft tight.
    5. Transmit power from one shaft to another.

24. Some of the advantages of mechanical seals over packing include
    1. Continual adjusting, cleaning, or repacking is not required.
    2. Lower initial cost.
    3. Pump does not have to be dismantled for repair.
    4. They last longer, thus resulting in labor savings.
    5. Usually there isn't any damage to shaft sleeve when they need replacing.

25. What information must be on a warning tag attached to a locked out switch?
    1. Directions for removing tag.
    2. Name of company that printed warning tag.
    3. Name of equipment.
    4. Signature of person who locked out switch and who is the only person authorized to remove tag.
    5. Time to unlock switch.

26. Maintenance operators should not do actual electrical repairs or troubleshooting because
    1. Costly damage can be done to equipment by unauthorized persons.
    2. It is too dangerous.
    3. Many are not adequately trained.
    4. They realize their own limitations regarding electrical work.
    5. This is a highly specialized field.

27. Maintenance of pneumatic ejectors includes
    1. Cleaning air strainer between ejector receiver and main air valve.
    2. Cleaning the interior of the pots to remove grease.
    3. Inspecting valves, floats and electrical controls for proper operation.
    4. Maintaining the motor and air compressor.
    5. Observing several cycles to be sure everything is operating properly.

28. **Electrical equipment can be damaged by**
    1. Corrosive atmospheres.
    2. Dust.
    3. Heat.
    4. Humidity.
    5. Vibration.

29. **Lift station electrical equipment protective devices may consist of**
    1. Circuit breakers.
    2. Circuit overload devices.
    3. Fuses.
    4. Motor overload devices.
    5. Voltage meters.

30. **Motors up to 100 horsepower should not exceed more than _______ starts per hour.**
    1. 1 or 2
    2. 2 or 3
    3. 4 or 5
    4. 5 to 10
    5. 10 to 20

REVIEW QUESTIONS

31. Safety precautions that must be considered during underground work include
    1. Adequate ventilation.
    2. Protection from cave-ins.
    3. Protection of private property.
    4. Protection of the operator from traffic.
    5. Protection of the public from injury.

32. Selection of proper shoring and use of shoring requires consideration of
    1. Access to construction work area.
    2. Operator safety.
    3. Pedestrian safety.
    4. Soil conditions.
    5. Trench location.

End of Objective Test

CHAPTER 10

SEWER REHABILITATION

by

Rich Thomasson

TABLE OF CONTENTS

CHAPTER 10. Sewer Rehabilitation

PAGE

OBJECTIVES 238

GLOSSARY 239

10.1 Program Formulation 240
  10.11 Historical Background 240
  10.12 Program Definitions 240
  10.13 Implementation 245

10.2 Evaluation of Conditions 245
  10.21 Purpose of Sewer System Evaluation 245
  10.22 System Problems 245
  10.23 Hydraulic Aspects 245
  10.24 Structural Aspects 253

10.3 Setting Up A Rehabilitation Program 255
  10.31 Data Collection 255
  10.32 Preliminary Statement of Needs 255
  10.33 Cost Analysis 255
    10.331 Failure Consequences 256
    10.332 Capital Costs of Repair Alternatives 256
  10.34 Setting Priorities 256
  10.35 Cost-Effectiveness Analysis 257

10.4 Methods of Rehabilitation 257
  10.41 Excavate and Replace 257
  10.42 Chemical Grouting 262
  10.43 Shotcrete 263
  10.44 Insituform 263
    10.441 Description of Process 263
    10.442 Preliminary Work 263
    10.443 Basic Equipment and Materials 263
    10.444 Installation Procedure 269
    10.445 Reinstatement of Services 277
    10.446 Advantages of Insituform Method 278

10.45 Polyethylene Pipe Lining 278
  10.451 Why Line Sewers? 278
  10.452 Preliminary Work 278
  10.453 Equipment 279
  10.454 Inserting Liner in Mains 279
  10.455 Lining and Connecting Service Laterals 281
  10.456 Sealing the Space in the Manholes 286
  10.457 Thank the Public 286
10.46 Other Methods 286
10.47 Service Connections 286
10.48 Manholes 287
10.5 Additional Reading 288
SUGGESTED ANSWERS 291
OBJECTIVE TEST 293

OBJECTIVES

Chapter 10. SEWER REHABILITATION

After completion of Chapter 10 you should be able to do the following:

1. Evaluate the condition of a sewer,
2. Determine the need for sewer rehabilitation,
3. Establish priorities for a sewer rehabilitation program,
4. Identify the various sewer rehabilitation methods,
5. Select the appropriate sewer rehabilitation method,
6. Implement and complete a rehabilitation project, and
7. Notify and cooperate with the public during a rehabilitation project.

GLOSSARY

Chapter 10. SEWER REHABILITATION

FLOW ISOLATION FLOW ISOLATION

A procedure used to measure inflow and infiltration (I/I). A section of sewer is blocked off or isolated and the flow from the section is measured.

INFILTRATION (IN-fill-TRAY-shun) INFILTRATION

The water entering a sewer pipe, including service connections, from the ground. Defective pipes, pipe joints, connections or manhole walls are a few of the common locations where infiltration may occur.

INFILTRATION/INFLOW (I/I) INFILTRATION/INFLOW (I/I)

The total quantity of water from both infiltration and inflow without distinguishing the source.

INFLOW INFLOW

The water discharged into a sewer system and service connections from such sources as, but not limited to, roof leaders, cellar, yard and area drains, foundation drains, cooling water discharges, drains from springs and swampy areas, around manhole covers or through holes in the covers, cross connections from storm and combined sewer systems, catch basins, storm waters, surface runoff, street wash waters or drainage. See INTERNAL INFLOW.

INTERNAL INFLOW INTERNAL INFLOW

Non-sanitary or industrial wastewaters generated inside of a domestic, commercial or industrial facility and being discharged into the sewer system. Examples are cooling tower waters, basement sump pump discharge waters, continuous flow drinking fountains, and defective or leaking plumbing fixtures.

INVERSION INVERSION

An Insituform process in which the insitu tube or liner is turned inside out (inverted) during the installation of the liner.

LIFE-CYCLE COSTING LIFE-CYCLE COSTING

An economic analysis procedure that converts all costs associated with a sewer during its useful life to a present worth or present cost in dollars.

PROMOTED PROMOTED

The mixture of resin and catalyst ready to have heat applied to cause (promote) curing in place.

SSES SSES

Sewer **S**ystem **E**valuation **S**urvey.

STRETCH STRETCH

Length of sewer from manhole to manhole.

SURCHARGE SURCHARGE

Sewers are surcharged when the supply of water to be carried is greater than the capacity of pipes to carry the flow. The surface of the wastewater in manholes rises above the top of the sewer pipe, and the sewer is under pressure or a head, rather than at atmospheric pressure.

CHAPTER 10. SEWER REHABILITATION

10.1 PROGRAM FORMULATION

10.11 Historical Background

In the past, the primary reason for rehabilitating a sewer was to restore the structural integrity of a line that had failed and, as a consequence, discharged raw wastewater into the environment. Today, however, the situation is much more complex. A large number of factors contribute to the rapidly declining integrity of major portions of the wastewater collection systems throughout the country.

To begin with, many of the collection systems in use today are very old and the materials used in their construction have lost their structural integrity due to corrosion and natural deterioration from use. This gradual breakdown allows greater infiltration, particularly during periods of heavy rainfall and under high groundwater conditions. The additional flows, in turn, generally produce two negative outcomes: 1) the *SURCHARGED*[1] sewer flows accelerate deterioration of the system and allow leakage into the environment (Figures 10.1 and 10.2); and 2) the increased inflow/infiltration overloads the treatment facilities to the point where they sometimes fail and discharge partially treated wastewater into the environment.

Other factors that contribute significantly to the deterioration of collection systems include rapid system expansion to keep pace with population growth in some areas. Not only can expansion tax the entire system, but it may result in a diversion of effort and attention away from the long-term preservation of existing facilities. Another effect of population growth is the stress that is created by vibrations from construction and the laying of roadways over sewer systems. Sewer systems also are failing due to unstable foundation soils or improper pipe bedding material.

A smoothly functioning sewer system is a service the public has come to take for granted. Because the system is largely out of sight, there is little awareness of its importance or of the serious consequences that result from continued neglect. As more and more large municipal systems reach the end of their useful lives, major programs of systematic rehabilitation will have to be undertaken. An ongoing program of long-range analysis and rehabilitation could greatly extend the serviceability of existing systems, could reduce operating costs, could reduce the need to expand the system, and could protect the environment from the consequences of a major collection system failure.

This chapter will explain how to analyze the condition of your present system, how to calculate the costs and benefits of needed repairs, and how to make the repairs using a variety of commonly accepted methods.

10.12 Program Definition

The first step in defining the rehabilitation program is to develop a comprehensive, written description of the major parts of your collection system. No program can be successful without first identifying all of the collection system components so you must begin by conducting an inventory of the system. Analysis of the condition of the system can then be handled in an orderly process. Once the analysis has been completed, you will be in a position to set the goals of your rehabilitation program.

Numerous records are available to a utility for the proper completion of the sewer system inventory phase of the program. Some of these major sources of information are as follows:

1. As-built drawings,
2. Maintenance complaint history files,
3. Construction reports,
4. Maintenance repair and inspection reports (Figure 10.3),
5. Interviews of key maintenance personnel, and
6. Updated maps of the sewer system (Figure 10.4).

Using the original construction and as-built drawings as a guide, conduct a field verification of the sewer system to identify changes made to the system during the intervening years. Key collection system personnel can assist you in identifying changes that have occurred since the original installation of the system. The repair records are also an extremely important resource for identifying changes to the

---

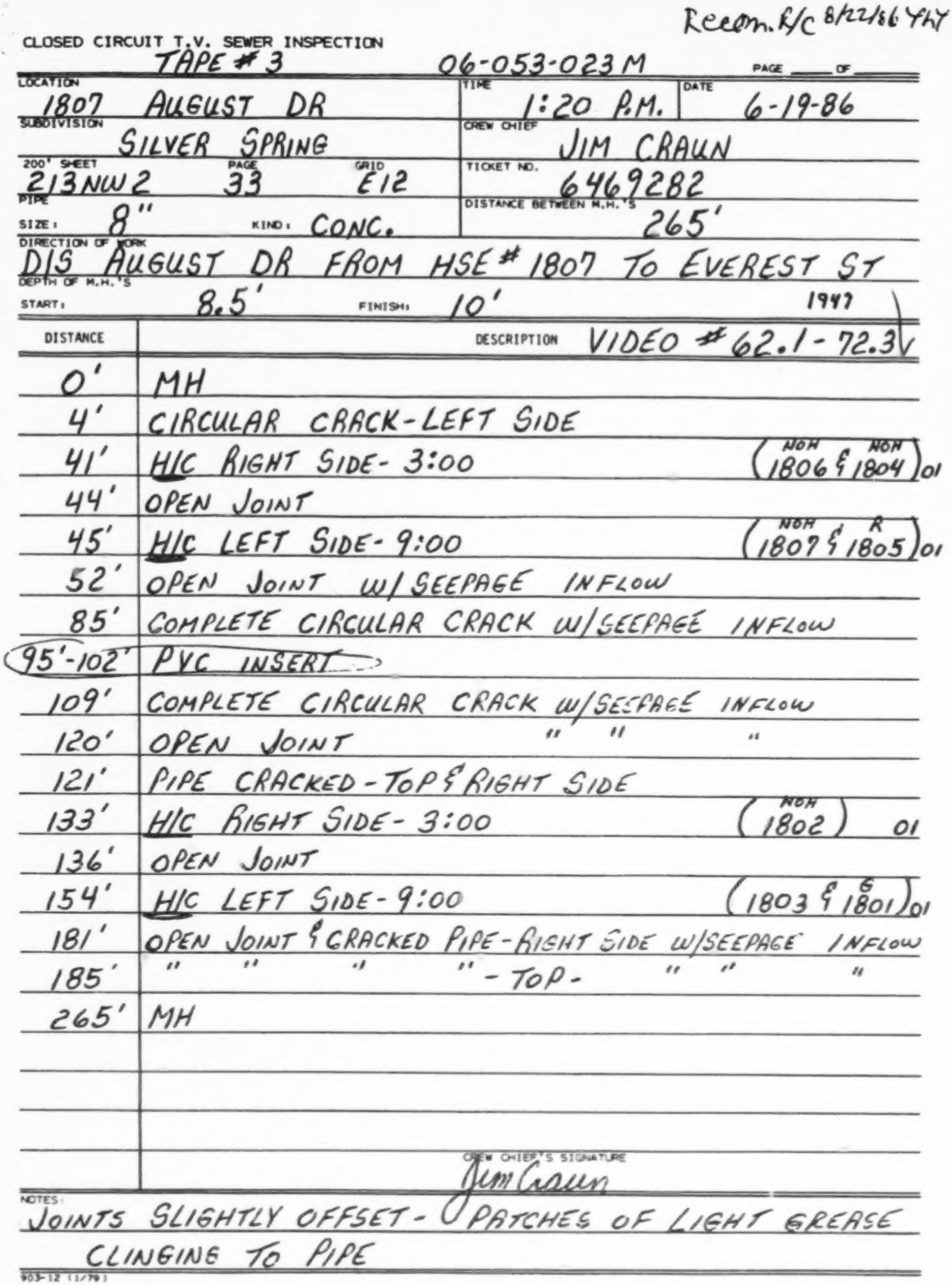
[1] *Surcharge. Sewers are surcharged when the supply of water to be carried is greater than the capacity of pipes to carry the flow. The surface of the wastewater in manholes rises above the top of the sewer pipe, and the sewer is under pressure or a head, rather than at atmosphere pressure.*

Fig. 10.1 Sewer leaking to the environment

263

[illegible]

268



Recom. R/C 8/22/86 YHY

CLOSED CIRCUIT T.V. SEWER INSPECTION

TAPE # 3 06-053-023 M PAGE ____ OF ____

LOCATION 1807 AUGUST DR		TIME 1:20 P.M.	DATE 6-19-86
SUBDIVISION SILVER SPRING		CREW CHIEF JIM CRAUN	
200' SHEET 213NW2	PAGE 33	GRID E12	TICKET NO. 6469282
PIPE SIZE: 8"	KIND: CONC.	DISTANCE BETWEEN M.H.'S 265'	

DIRECTION OF WORK D/S AUGUST DR FROM HSE # 1807 TO EVEREST ST

DEPTH OF M.H.'S START: 8.5' FINISH: 10' 1947

DISTANCE	DESCRIPTION VIDEO # 62.1 - 72.3
0'	MH
4'	CIRCULAR CRACK-LEFT SIDE
41'	H/C RIGHT SIDE- 3:00 (NOH 1806 & NOH 1804) 01
44'	OPEN JOINT
45'	H/C LEFT SIDE- 9:00 (NOH 1807 & R 1805) 01
52'	OPEN JOINT W/SEEPAGE INFLOW
85'	COMPLETE CIRCULAR CRACK W/SEEPAGE INFLOW
95'-102'	PVC INSERT
109'	COMPLETE CIRCULAR CRACK W/SEEPAGE INFLOW
120'	OPEN JOINT " " "
121'	PIPE CRACKED - TOP & RIGHT SIDE
133'	H/C RIGHT SIDE- 3:00 (NOH 1802) 01
136'	OPEN JOINT
154'	H/C LEFT SIDE- 9:00 (1803 & G 1801) 01
181'	OPEN JOINT & CRACKED PIPE - RIGHT SIDE W/SEEPAGE INFLOW
185'	" " " " - TOP - " " "
265'	MH

CREW CHIEF'S SIGNATURE Jim Craun

NOTES: JOINTS SLIGHTLY OFFSET - PATCHES OF LIGHT GREASE CLINGING TO PIPE

903-12 (1/79)

Fig. 10.3 Sewer inspection report

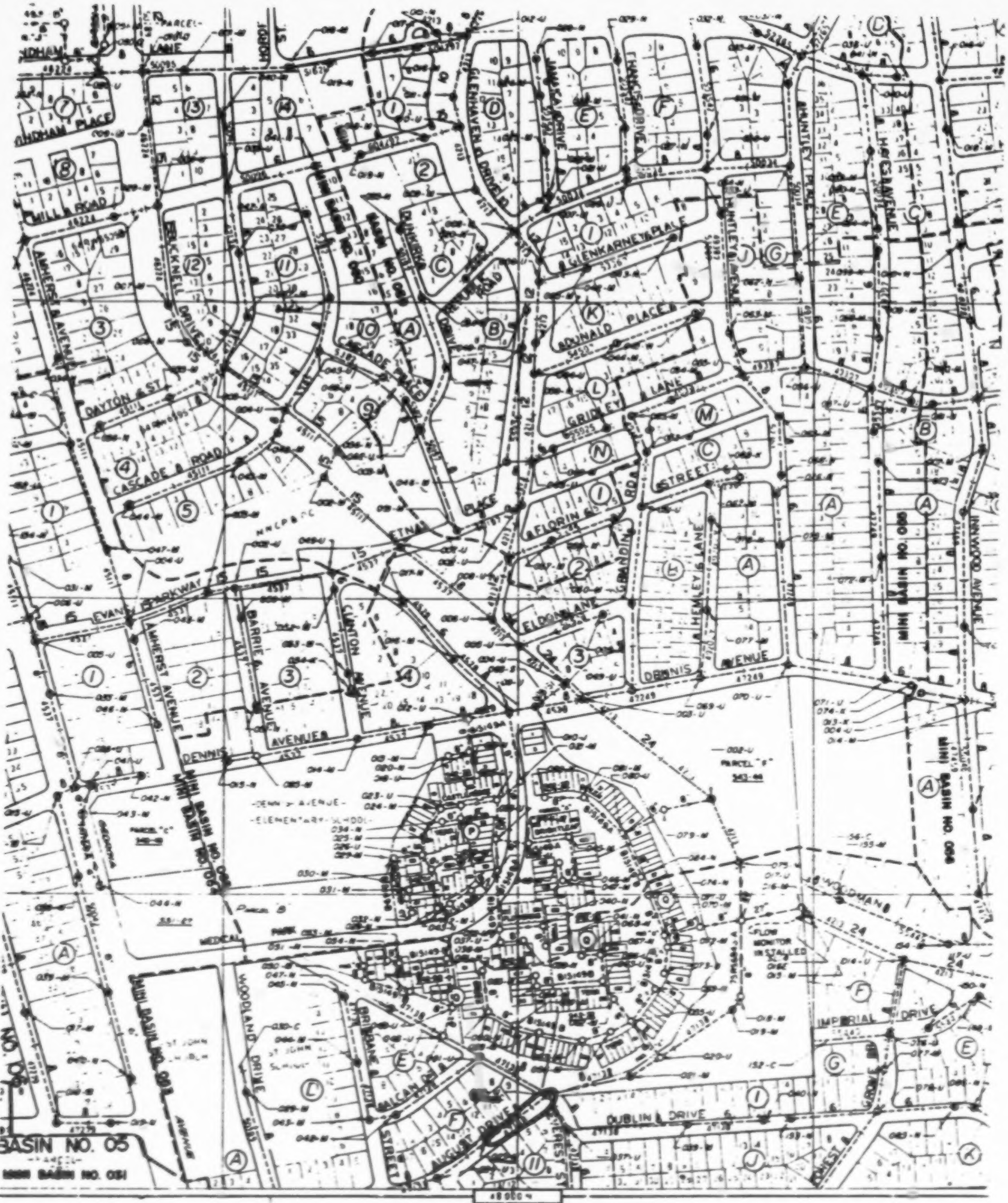

WYNDHAM PLACE
MILL ROAD
AMHERST AVENUE
DAYTON ST.
CASCADE ROAD
CASCADE PLACE
GLENHAVEN DRIVE
GLENKARNEY PLACE
GRIDLEY LANE
EVANS PARKWAY
BARRIE AVENUE
CLINTON AVENUE
DENNIS AVENUE
DENNIS AVENUE ELEMENTARY SCHOOL
HUNTLEY AVENUE
INWOOD AVENUE
WOODLAND DRIVE
IMPERIAL DRIVE
DUBLIN DRIVE
AUGUST DRIVE
FLOW MONITOR INSTALLED
BASIN NO. 05
MINI BASIN NO. 051
ANITARY COMMISSION
RKING MAP
213NW2
REVISED OVERLAY
REVISED

Fig. 10.4 Map of sewer system

sewer system. Records can indicate areas where problems occur regularly, repairs are frequent, maintenance is excessive and additions have been made to the system. Your goal is to prepare an inventory that accurately identifies and describes the present condition of each and every component of the sewer system.

Each jurisdiction uses its own unique mapping system to record the overall physical layout of the sewer system. These maps normally include the location of junctions at manholes, size of sewer pipe, reference to original contract and general location of the sewer in relation to roads and other utilities.

Most utilities store all their records in a manual card system and plan file system. Some utilities have been fortunate enough to transfer their records to a personal computer file or, less often, to a mainframe computer. Also, some mapping has been converted to computer-aided drafting (CAD) systems. Whichever mode of record storage is available to you, it must be organized properly if it is to be an effective tool in the inventory process.

The purpose of a physical survey is to identify the problems that created the need for rehabilitation projects and thereby preclude the potentially disastrous and costly consequences of sewer deterioration. Closed-circuit television, pipe flow tests, computer flow models and visual inspections are some of the many techniques available to the utility for evaluating the system condition. Capacity evaluations can assist in determining whether additional capacity is required; this has a direct bearing on whether or not rehabilitation is needed or total replacement by construction of a larger main is required. Decisions are also based on the costs associated with the rehabilitation and the reliability of the sewer system. The condition analysis can be a major tool in setting priorities in your program.

10.13 Implementation

Most utilities will find this step to be the one that raises the most problems. It is usually not too difficult for a utility to develop a program and to identify the key elements of the rehabilitation program. The major stumbling block is to identify the staffing to handle the program and to secure the funding to actually accomplish rehabilitation work. The levels of funding and staffing will directly affect the level of completeness of your rehabilitation program.

After the arrangement of financing and staffing, the actual design and construction can be initiated. In conjunction with the design stage, you should also review your present maintenance program to determine areas of revision which will fit into the rehabilitation program to insure a coordinated effort of maintenance and rehabilitation.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 291.

10.1A Why is there a need for sewer rehabilitation?

10.1B Why must a physical survey of a collection system be conducted before a sewer rehabilitation project can start?

10.1C Why must the present maintenance program be reviewed before the start of a sewer rehabilitation program?

10.2 EVALUATION OF CONDITIONS

10.21 Purpose of Sewer System Evaluation

Since the passage of Public Law 92-500 in 1972, there has been increasing pressure to reduce the Infiltration/Inflow (I/I) problems in existing sewer systems. With this law, the EPA issued guidelines for conducting I/I evaluations as a step towards reducing the unplanned-for I/I flows. The evaluation process consists of two parts: 1) I/I analysis, and 2) the sewer system evaluation survey (SSES).

The main reason for this new emphasis was to reduce the hydraulic loads on the sewer system and the treatment facilities. Excessive hydraulic loads increase treatment costs, result in the bypassing of untreated wastewater to the environment and can result in structural failure of weakened collection systems. The remainder of this section discusses the proper procedures for conducting I/I evaluations.

10.22 System Problems

The high I/I and structural deterioration of sewer systems can have serious impacts on the operation of the system. The higher flows result in reduced capacity of the sewer lines for handling peak sanitary flows and remove the additional capacity reserved for growth. In many cases these excessive flows and deteriorated conditions result in the construction of relief sewers before they might otherwise be needed.

The major problem from a public relations viewpoint is back-flooding into private property as a result of the surcharge or overloading of the sewer mains. The public is also very aware of the degradation of the environment due to overflows from storm drains and natural streams. The higher flows can also result in damage and accelerate wear of equipment at pumping stations and treatment plants, and even the treatment processes are adversely impacted by the high flows.

10.23 Hydraulic Aspects

Flow monitoring is the primary tool for identifying high I/I. The purpose of flow monitoring is to measure variations in flow components over time to identify peak and minimum flow conditions. The flow monitoring phase is set up to identify and measure the three flow components: base flow, infiltration and inflow.

Base flow can be determined in several ways. Use water consumption records as a basis and adjust for inaccuracies due to unmetered connections, water meter inaccuracies, irrigation and seasonal peaks. Another method is to measure minimum flow rates (to determine infiltration rates) and then subtract this amount from metered flow during dry weather. A third way to determine base flow is to evaluate water consumption estimates for residents upstream of the metering location. By examining water usage or water meter records, amount of water used or consumed by upstream residents (lawn watering, water used in manufacturing processes such as soda pop) and amount of water returned to the sewers (flushing toilets, dishwater, industrial wastewaters), the expected base flow can be estimated. Flows greater than the expected base flow can be considered to come from inflow and infiltration sources.

Infiltration is calculated by subtracting base flow from total metered flow during dry weather. Infiltration can also be computed by compilation of flow isolation measurements. Flow isolation measurements are obtained by blocking off sections of a sewer and then measuring the flow in the sewer. All unaccounted for flows or all flows when all known sources are blocked off are considered infiltration flow.

Inflow is measured during wet weather and is calculated by subtracting base flow and infiltration from total flow data recorded during wet weather.

Exfiltration can be a serious problem in some areas where exfiltration flow can contaminate groundwater used for public drinking water supply. Exfiltration can be measured by using the same techniques used to measure inflow/infiltration, except we are looking for a *REDUCTION* in expected flows.

Flow monitoring is the backbone for the hydraulic analysis phase of the sewer evaluation. Both temporary and permanent metering sites are used to collect the data. Temporary metering sites provide the majority of the data required to evaluate sewer flows. The permanent site at pumping stations and treatment plants can be used to provide additional backup data.

You will need to plan the flow-metering phase well in advance so that the maximum amount of quality data can be gathered for the most reasonable cost. Consider also the level of accuracy you wish to achieve. Next, figure out how long you will have to measure flows to produce the required amount of data. This is an important decision because it directly affects the type of recording equipment and the data storage capacity you will need. Some methods of data storage include strip charts, circular charts, magnetic tape and remote telemetering. The magnetic tape and telemetering allow much faster gathering and processing of the flow data. The one negative side of this new technology is that it is not easy to check the data to see how the meter is operating in the field.

Each flow-metering program requires preplanning of the sites by actual field surveys. Do not rely on drawings to provide accurate hydraulic characteristics of a metering site. When the conditions are not found to be optimal, then select an alternate site. The best manhole locations for open channel metering will not have any change in horizontal direction (pipe alignment) or any vertical change (pipe slope or elevation). In addition, the flow should be a smooth flow and have a moderate velocity to assist in self-cleaning of the channel.

The initial field data to be collected and recorded when you are evaluating proposed metering sites should include the following items:

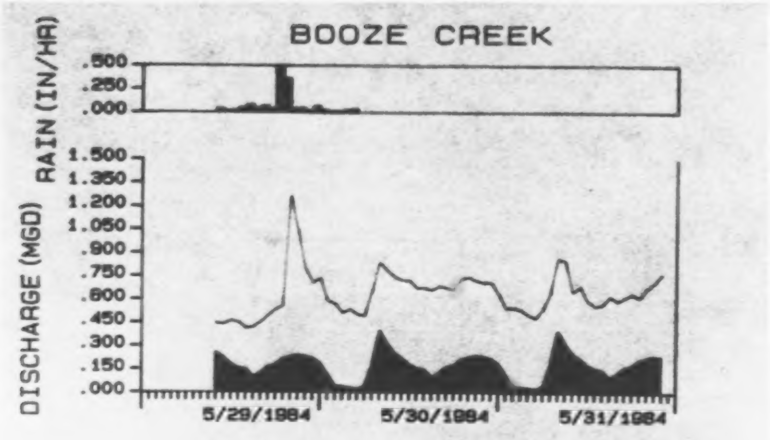
1. Flow depth,
2. Sediment load,
3. Pipe size and shape,
4. Accessibility,
5. Manhole location, and
6. Surcharge potential.

It is very important to determine the possible surcharge potential for the metering location. Surcharging results in non-uniform flow or backflow conditions which will result in faulty flow meter readings. Additional equipment, such as pairs of depth recorders or flow velocity and depth-recording equipment, may be required to properly handle the surcharge readings. In every case, actual and potential flow conditions will influence your selection of metering equipment.

The use of weirs and flumes will usually increase the accuracy of your flow metering program since weirs are one of the most accurate measuring devices for low flow conditions. They are susceptible to inaccurate readings when debris, rags or sludge build up behind or on the weir. Devices of this type usually reduce the hydraulic capacity of the sewer. Therefore, close coordination of the metering program with system maintenance personnel is imperative to avoid adverse impacts to the system and metering equipment from normal, daily maintenance activities.

Flow data evaluation involves the production of flow parameters and hydrographs for each location metered. As stated earlier the data can be analyzed manually or automatically, depending on which equipment is used. Computers provide increased accuracy and speed up the processing of the metered data. Analyze the data on preset intervals, normally 15-minutes, 30-minutes or 60-minutes. Determine the flow rates for each interval and then calculate a total daily volume. Check individual hourly measurements to determine peak hourly rates. Construct hydrographs with each data point falling at the appropriate interval (Figure 10.5).

Another important hydraulic consideration is the measurement of precipitation. The correlation between rainfall and flow metering data is important when calculating the amount of inflow entering the sewer system. Precipitation data should include rainfall intensity, duration of the rainfall and total rainfall volume. A lot of this rainfall data can be gathered from agencies that continuously monitor rainfall data such as the weather bureau or water resources agencies. After a review of the data available, select the locations and types of rainfall-measuring devices required for your flow metering program. Since precipitation runoff is usually highly correlated with inflow, compare sewer flows and inflow flows with precipitation data. If sewer flows and inflow flows increase when precipitation values increase, then this is an indication that the collection system has inflow problems and that the sources should be identified and controlled or eliminated. Try to locate rainfall-measuring devices



Plot of all of the domestic hourly consumption and the Qtotal.

Fig. 10.5 Hydrograph of flow vs. time

where they can collect accurate measurements of precipitation data without interference with buildings or by vandals.

Measurement of groundwater is a very important component in the hydraulic analysis phase. The location of the groundwater level and measurement of the level changes are the two most important facets of this phase. Normally, either a piezometer (PEA-ZAHM-uh-ter) or a manhole gage is used for sewer evaluations. The manhole gages (Figure 10.6) are less expensive, easier to install, but provide data of less quality and can become clogged easily. The piezometer (Figure 10.7) is a more permanent installation, provides higher quality data, and is less likely to clog, but it is more expensive. Groundwater levels are recorded on a periodic basis (daily or with tidal fluctuations depending on location) during flow-metering periods. The frequency would be increased during the metering period to provide better data correlation. Levels of infiltration (measured in gallons per day or gallons per day per inch of sewer diameter) are determined by plotting groundwater levels versus time in comparison with metering data. Also, the groundwater data can be used to more effectively schedule flow isolation and television inspection because the higher the groundwater, the greater the expected infiltration flow.

Night flow isolation is used to determine the amount of extraneous water entering a section of sewer. It is used to pinpoint the *STRETCHES*[2] of sewer which have the excessive infiltration so they can be targeted for additional inspection. It cannot be stressed enough that accurate maps are essential for the success of the isolation program. Accurate measurement point identification is critical. A succesful isolation program depends largely on knowing the exact location of groundwater infiltration measurements as they relate to the sewer stretch groundwater level. Other sources of excess flows include roof drains and yard drains illegally connected to the sewer.

Once you have determined that there is excessive infiltration in a particular area, the next step is to identify the specific locations of leaks. There are three major sources where rainfall-induced I/I enters a sewer system. They are the following:

1. Sewer mains,
2. Manholes, and
3. Sewer house connections.

Each major source has various types of leaks which contribute to the rainfall-induced I/I.

A. Sewer Mains
   1. Point source leak (Figure 10.8)
   2. Defective joint leak (Figure 10.9)
   3. Service tap point source leak
   4. Main line multiple leaks (Figure 10.10)
   5. Storm drain cross-connection leak

B. Manholes
   1. Holes in cover
   2. Worn cover ring
   3. Between ring and brickwork (Figure 10.11)
   4. Through brickwork under ring
   5. Through manhole wall
   6. Through manhole joints
   7. At plugged stub in manhole
   8. Around sewer pipes entering manhole (Figure 10.12)
   9. Through base of manhole

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[2] *Stretch. Length of sewer from manhole to manhole.*

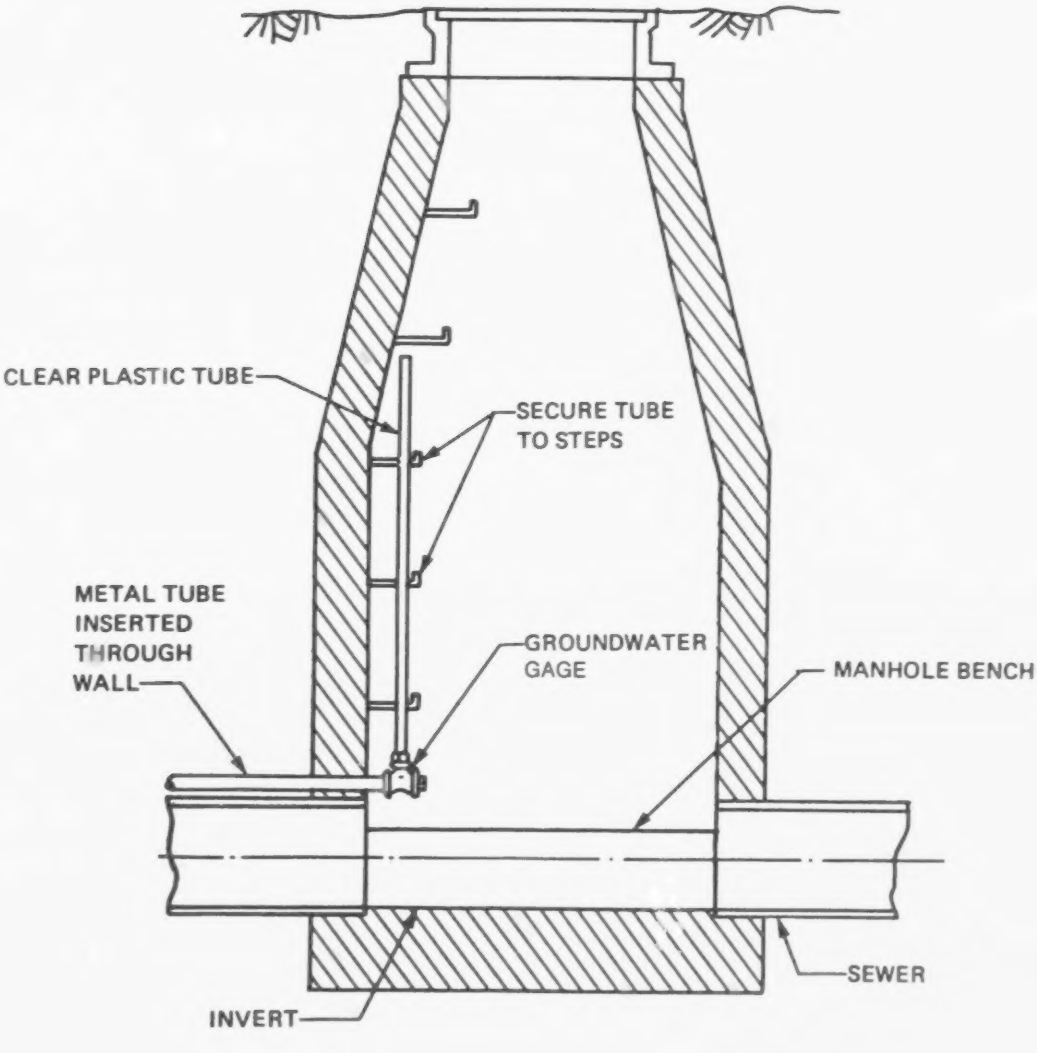

CLEAR PLASTIC TUBE
SECURE TUBE TO STEPS
METAL TUBE INSERTED THROUGH WALL
GROUNDWATER GAGE
MANHOLE BENCH
SEWER
INVERT

Fig. 10.6 Typical static groundwater gage installation

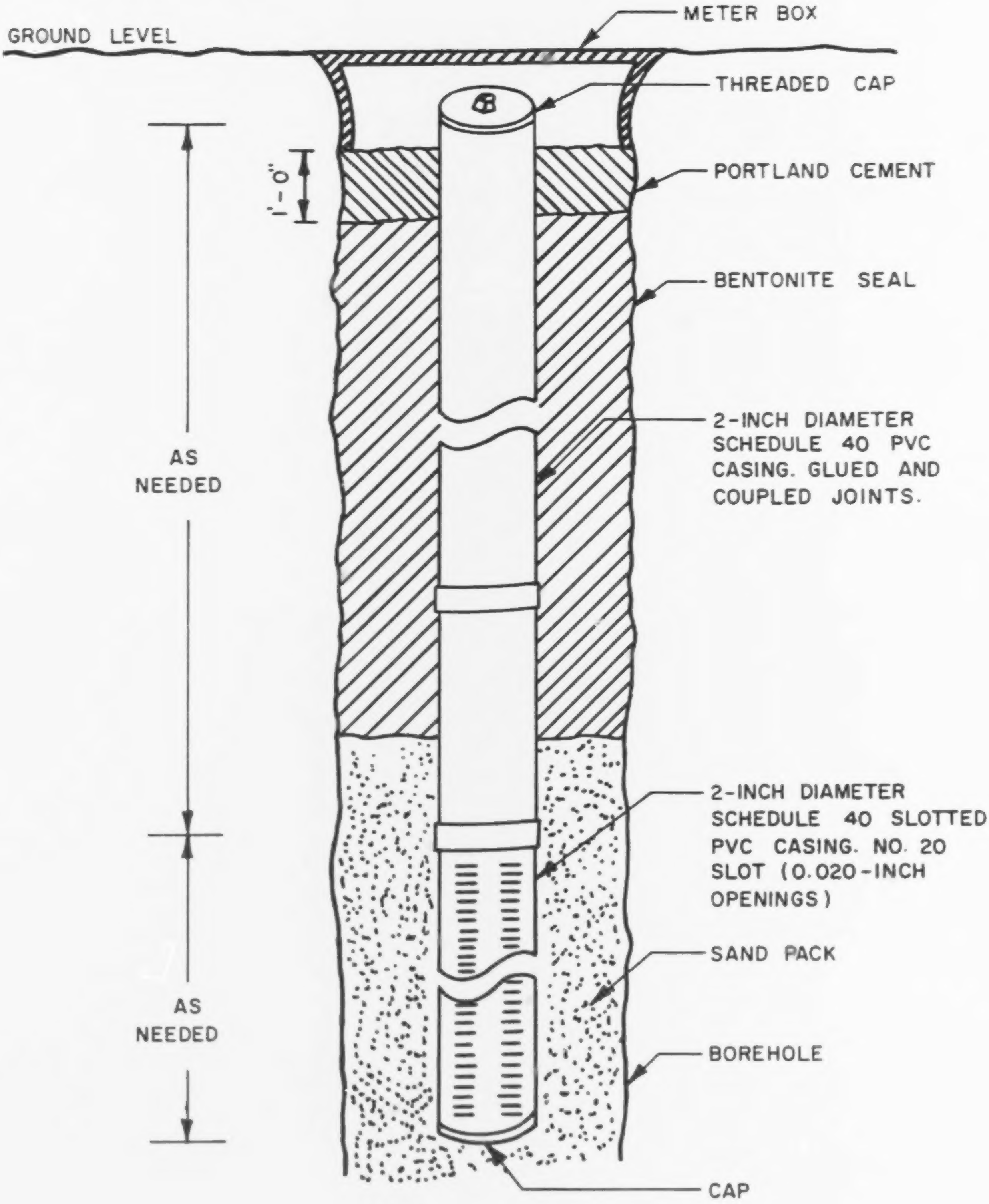

METER BOX
GROUND LEVEL
THREADED CAP
PORTLAND CEMENT
1'-0"
BENTONITE SEAL
2-INCH DIAMETER SCHEDULE 40 PVC CASING. GLUED AND COUPLED JOINTS.
AS NEEDED
AS NEEDED
2-INCH DIAMETER SCHEDULE 40 SLOTTED PVC CASING. NO. 20 SLOT (0.020-INCH OPENINGS)
SAND PACK
BOREHOLE
CAP

Fig. 10.7 Piezometer monitoring well installation

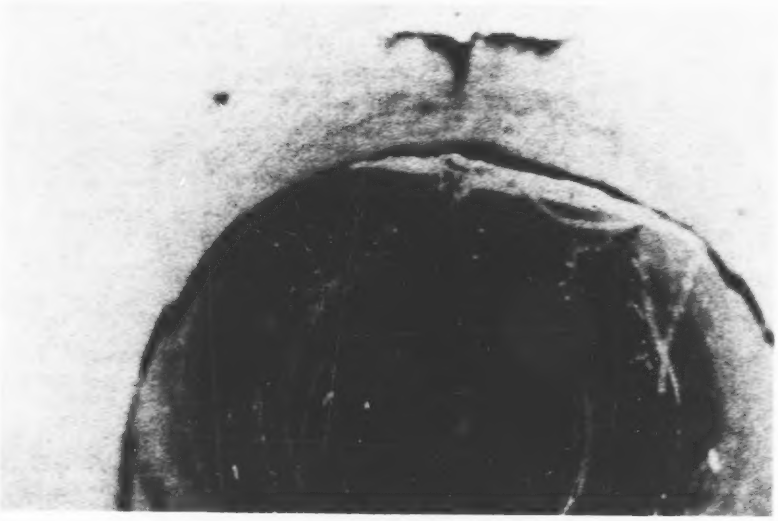


Fig. 10.8 Point source leak

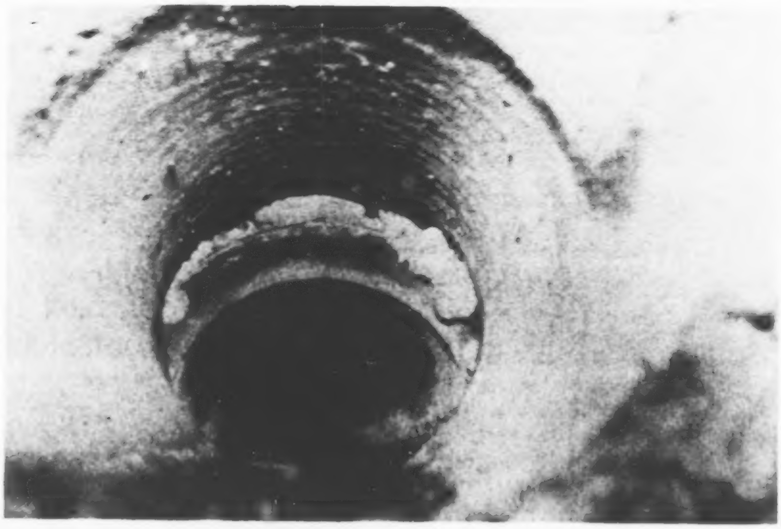


Fig. 10.9 Defective joint leak

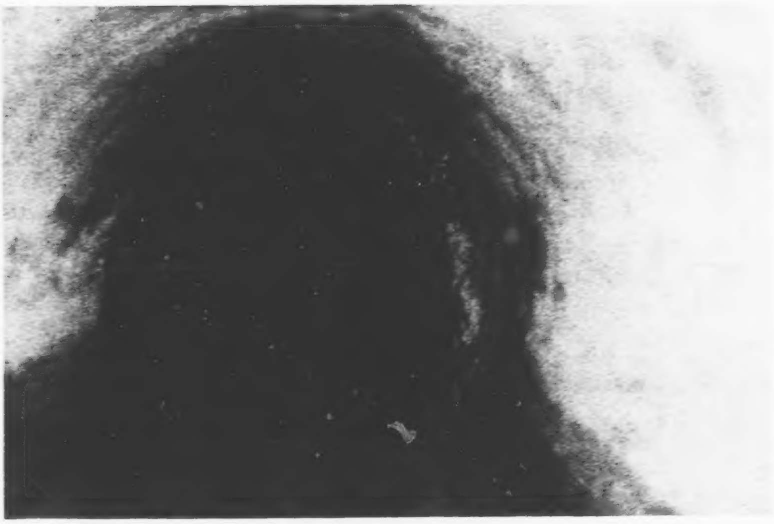


Fig. 10.10 Main line multiple leaks

Fig. 10.11 I/I between manhole ring and brickwork

Fig. 10.12 I/I around sewer pipe entering manhole

Many times the bedding around sewer pipes will serve as a drain and convey groundwater down the pipe trench to the manhole. This water will then enter the sewer through defects in the manhole.

C. House Service Connections

1. Point source leak
2. Joint leaks
3. Multiple damage leaks
4. Defective cleanout leak
5. Storm drain cross-connection
6. Foundation drain hookup
7. Roof drain connection
8. Surface or yard drain connection

Several techniques are used to locate rainfall-induced leaks, including smoke testing (Figure 10.13) and dye-water flooding.

Fig. 10.13 Smoke testing

Smoke testing is a quick and inexpensive method of detecting I/I sources in a sewer system. This approach is most effective in detecting inflow from storm drain cross-connections, point source leaks, roof connections, foundation drains, faulty manholes and sometimes main line defects. The method is not effective during high groundwater conditions or in sewers where sags or water traps are suspected or where sewers flow full. The smoke will not be able to travel through the sewer section when a section is full of water and can result in misleading conclusions. Smoke testing is also ineffective when the ground is saturated, frozen or covered with snow, because the smoke will not be able to escape to the surface even though there may be defects in the sewer system. Windy conditions can also distort your readings and result in faulty conclusions.

To generate smoke for this test, use commercially available smoke bombs of three-minute or five-minute duration. The smoke is non-toxic, odorless and non-staining. Careful preparations must be made before you start the smoke test. Coordinate your activities with the police and fire departments to avoid false fire alarms. Also, notify each resident in the test area that a test will be taking place and explain the procedures as well as what they might expect to see.

The procedures for properly conducting a smoke test are as follows:

1. Notify police, fire officials and residents;
2. Isolate the section of sewer to be tested;
3. Prepare a detailed sketch of the test area;
4. Make enough smoke to completely fill the stretch being tested;
5. Using an air blower, force smoke into the isolated area;
6. Walk area thoroughly (several observers are recommended) to observe leaks;
7. Record precise locations of leaks on sketch; and
8. Take photographs of leaks (try to include identifying landmarks) to create a permanent record of the test results.

Refer to Section 5.5, "Smoke Testing," pages 225 to 231, in Volume I for details on smoke testing procedures.

When there is a positive reading of smoke exiting to the atmosphere, it clearly pinpoints I/I sources. When no smoke is visible, do not automatically conclude that there are no defects. As stated earlier, there may be other conditions that interfered with the results. If there is no visible smoke exiting from the system and I/I appears to be a problem in the area, try dye-water flooding (next paragraph) or televising the system during periods of high groundwater and/or precipitation.

Dye-water flooding or dye testing is another rainfall simulation technique used to identify defects that allow leakage into sewers during rainfall. It also can be effective in quantifying the volumes of I/I which can enter the specific defects. Areas that are prime candidates for dye-water flooding are:

1. Storm drains that run parallel to or cross sewers or house connections in which top-of-pipe elevations are higher than the invert elevations of the sewers;
2. Drainage ditches, streams and water ponding areas located in close proximity to or over sewers or house connections;
3. Yard drains, areaway drains, foundation drains, roof drains and abandoned building sewers; and
4. Specific problem areas identified in other tests for which additional data are needed.

The procedure is very simple and requires simple equipment. Plug the study stretches and fill the area with dye-water. The dyes are fluorescent for detectability, safe to handle, easily mixed in water, inert in (do not react with) soils and biodegradable. After the storm water areas are flooded or filled with the dyed water, observe the sewer system for the entry of the dyed water. In stretches that are suspected of having excess inflow, closed-circuit television can be used to quantify and pinpoint the leaks. Record the collected data on data sheets and make a sketch or map of the exact locations of leaks so they can be corrected. Also a dye solution may be prepared and dumped into a suspected illegally connected drain. Flush the drain with water and see if the dye washes into the sewer.

10.24 Structural Aspects

Structural integrity and defect identification should be integral parts of all sewer evaluations. Changes in the use of the land surface area over the sewers due to land use changes results in changes of loadings on the sewer pipe. In some cases the load changes exceed the designed strength of the pipe or manhole walls. Also, changes can result in additional traffic loading which was not included in the original design. Since there are many methods of rehabilitation, the sewer cover conditions must be evaluated in terms of present use as well as estimated for future uses.

The existing condition of the pipe must be evaluated. The existing condition has an effect on the strength of the pipe and on the hydraulic capacity of the pipe. Again, the rehabilitation method depends a great deal on the existing conditions identified. When examining for structural defects record the following information.

A. Sewer Pipe
   1. Type of pipe
   2. Pipe deflection (sag or bow in pipe)
   3. Joint separation or offset
   4. Cracked joints
   5. Root intrusion
   6. Circumferential and longitudinal cracks
   7. Crushed pipe
   8. Missing pipe
   9. Protruding taps
   10. Leaking joints
   11. Leaking tap
   12. Corrosion of pipe walls
   13. Pipe diameter (no longer round)

B. Manholes
   1. Type of material
   2. Wall condition
   3. Joint condition between manhole and frame
   4. Channel condition
   5. Joint condition where pipes enter manhole
   6. Precast joint condition
   7. Visible leakage
   8. Corrosion of walls
   9. Frame and cover condition
   10. Step condition

All utilities experience operation problems which can be directly attributed to defects. Some of the problems encountered are:

1. Overflowing manholes,
2. Backups into homes,
3. Sewers surcharging,
4. Exfiltration of wastewater,
5. Sunken areas over sewers,
6. Increased flows due to inflow/infiltration,
7. Sand and gravel in sewers, and
8. Grease buildup,
9. Odors from hydrogen sulfide due to low flows from exfiltration.

Most often problems are reported by the public. In some instances routine inspection programs will detect some of these conditions. All information must be recorded so that the history of problems can be identified with a particular stretch of sewer or a specific manhole.

Pipeline visual inspection involves internal inspection and surface inspection. Walking the surface along a sewer right-of-way can give much information on the sewer condition. Sunken areas, stream crossing condition of pipelines, areas of ponding water and water leakage from the soil along the right-of-way are all indications of the sewer defects.

Internal inspection of the sewer pipe involves lights and mirrors or closed-circuit television. The information gained by use of lights and mirrors is limited. Usually only a small portion of the sewer stretch can be viewed with these methods. Also, it is difficult to clearly identify the problems with this method.

The use of closed-circuit television (Figure 10.14) is the most effective method of identification and quantification of defects in sewer pipes. Reports can be made from the inspection and a permanent visual record of the inspection is available by use of video recordings. Constant updates in technology have resulted in the ability to televise small-diameter pipes as well as house connections. The technology has evolved from black and white to color closed-circuit television. The advantage of color is to give added depth perception to the inspection. A better evaluation of defects can be made as a result of this added depth perception.

A standard record procedure for reports made from the inspections must be established. This will assist in ready reference when searching for a particular report. Certain data should be gathered for each inspection report.

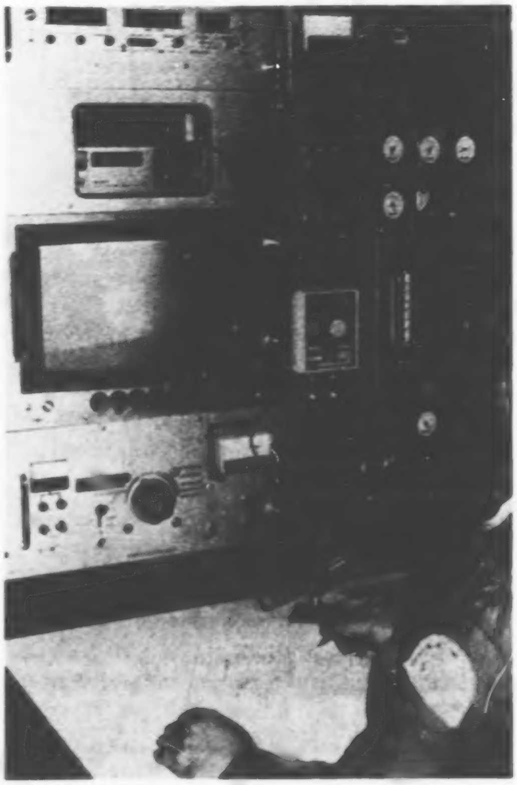


Fig. 10.14 Closed-circuit television

1. Length of stretch or inspection area
2. Pipe material and pipe diameter
3. Joint spacing and type
4. Location and quantity rating of root intrusion
5. Grease accumulation location
6. Joint separation location and severity
7. House service tap location, condition
8. Water level in sewers
9. Cracks, location and severity
10. Missing pipe
11. Pipe deflections
12. Sewer sags
13. Corrosion of walls

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 291.

10.2A Why is there an emphasis on the reduction of hydraulic inflow/infiltration loads on sewer systems and treatment facilities?

10.2B List the three flow components in a sanitary sewer.

10.2C Why must the possible surcharge potential for a metering location be determined?

10.2D Smoke testing is not effective under what conditions or circumstances?

10.2E What types of areas are suitable for dye-water flooding?

10.2F How can defects in sewer pipes be identified and quantified?

10.3 SETTING UP A REHABILITATION PROGRAM

10.31 Data Collection

Once you have completed the sewer system evaluation survey (SSES) of your system, you will have a great deal of raw data, including:

1. Inventory. A complete, itemized listing of all system components.
2. Maps. Complete, up-to-date maps of the system layout.
3. Condition of System. Detailed written reports of all significant leaks, cracks, collapsed pipes, and seriously deteriorated components. This record may include TV footage or videotapes.
4. Flow Data. Design specifications of flow capacities as compared with current flow measurements including base flow, infiltration, and inflow data. These should be organized in a format that indicates flow variations by time of day, time of year, and minimum and maximum flows.
5. Problem History. Historical data concerning problem areas such as repeated failures, adverse conditions (limited or hazardous access, for example), maintenance limitations, surcharges and flooding of homes and streets.
6. Treatment Facility Data. Data documenting frequency and severity of hydraulic overloads, discharge permit violations and plant bypasses. Compiling this information may take several months' work but it is essential for the next step in the decision-making process.

Compiling this information may take several months' work but it is essential for the next step in the decision-making process.

10.32 Preliminary Statement of Needs

Based on the information gathered in the system inventory, put together a list of needed repairs, in the order they are most urgently needed. At this point, don't be concerned with anything except the physical and operational condition of system components. If necessary, begin your list by grouping items in general categories such as:

INOPERABLE/Immediate Repair or Replacement Needed

DECLINING FAST/Frequent Breakdowns

OK FOR NOW/Troublesome

or:

OVERLOADED AND NEAR COLLAPSE

SEVERE I/I - FREQUENT FAILURES

PERIODIC OVERLOADS

Once you have identified these groups, try to assign priorities within groups. Mark the most urgently needed repair as "1" and the next as "2" and so on. If several items seem equally urgent, assign the same rating to each.

As an operator, your role in the process may end here. Depending on the complexity of your system and the size and structure of the agency's administration, you may or may not be a participant in the next phase of setting up a rehabilitation program. In either case, however, it is helpful to understand how the decision-making process will most likely proceed.

10.33 Cost Analysis

The third step in the process of setting up a rehabilitation program involves calculating what it will cost to implement various strategies. Usually there are four courses of action that can be taken:

1. Maintain the present system, as finances permit,

2. Replace the worst components, to the extent possible,
3. Relieve deteriorating or overloaded segments where conditions and finances permit, or
4. Rehabilitate to the extent possible.

In reality, of course, nearly every rehabilitation program will utilize a combination of strategies, perhaps by stepping up the preventive maintenance to extend the life of existing facilities; completely replacing a few stretches of sewer in immediate danger of collapse; providing some relief sewers to moderate flows in overloaded stretches; and gradually rehabilitating stretches of sewer that still function but are deteriorating as they approach the end of their useful life.

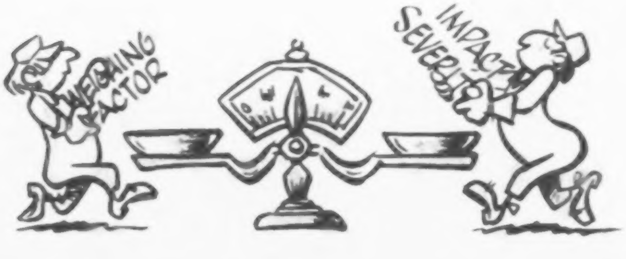
While keeping in mind the alternative strategies listed above, the decision-makers also must consider the financial aspects of rehabilitation. Major considerations are: 1) the consequences of system or component failure; 2) cost-effectiveness of corrective action; and 3) capital costs of various repair alternatives.

The material that follows is intended as a general introduction to calculation of the cost factors listed above. It is not a complete guide to making the calculations. Only in a very small utility or collection agency would operators normally be asked to undertake a cost analysis. You may be asked, however, to provide specific repair process recommendations or to give an opinion about the probable results of an action. It is hoped that by understanding the decision-making process, you will be better prepared to contribute your considerable knowledge and expertise at appropriate points in the process.

10.331 Failure Consequences

In cases where it is necessary to compare the relative costs of repairing one seriously deteriorated component versus another, it is useful to include consideration of what would happen if the components failed completely. This type of assessment is admittedly very subjective, but if done in a systematic manner, failure assessment allows us to take into account factors that are otherwise difficult to quantify in terms of dollars-and-cents calculations. For example, how does an agency measure the public relations value of a dependable, cost- effective system? Or, how does an agency take into account the impact of lost business to merchants during the six days their street is torn up for sewer repairs?

While it would be impossible to assign dollar values to such factors, it is possible to assign weighting factors and to classify the severity of a failure as light, medium, or heavy. Once this is done for each repair under consideration, it is possible to compare the impact and urgency of one repair against another, and then to set priorities. To do this, multiply the impact severity factor by the weighting factor for the Total Failure Index.



Each utility will have their own unique definitions of categories and will assign different weighting factors. The desired result, however, is to arrive at some method that reflects the true costs of a component or system failure. The Failure Matrix (Table 10.1) is a typical way of constructing such a system.

This matrix was prepared for a section of 48-inch sewer between two manholes in a downtown area of a city. If the sewer were to fail, both local service and tributary service would be disrupted. By multiplying the weighting factors times the severity factors, Service Disruption is given a value of 13. The greater the severity of the disruption, the greater the value. If this section of sewer fails, the disruption of traffic will have a disruption subtotal of 12. With traffic and utilities, however, there is an additional factor to be computed. The greater the depth of cover, the deeper the digging for repair and the greater the disruption. To account for this, multiply the traffic and utilities subtotal (12) times the depth of cover weighting factor (2) to arrive at the more complete subtotal for urban disruption which is 24. Next, combine the Service Disruption Subtotal (13) with the Urban Disruption Subtotal (24) to get the Total Failure Index of 37. Those sewers with the greatest values for their "Total Failure Index" will be the first sewers that should be repaired and/or rehabilitated.

TABLE 10.1 FAILURE MATRIX

		IMPACT SEVERITY			
CATEGORY	WEIGHTING FACTOR	LIGHT (1)	MEDIUM (2)	HEAVY (3)	TOTALS[b]
Service Disruption					
a. Local service	2		2		4
b. Tributary service	3			3	9
SUBTOTAL					13
Other Urban Disruption					
a. Traffic	3		2		6
b. Utilities	2			3	6
SUBTOTAL					12
c. Depth of cover	2[a]				
SUBTOTAL - Urban Disruption					24
TOTAL Failure Index (24 + 13)					37

[a] This factor will have an impact on traffic and utilities. Multiply the subtotal for Urban Disruption by this factor to get the overall Urban Disruption Total (2 x 12 = 24)

[b] Total values are obtained by multiplying weighting factor value (2) times impact severity value (2) or (2 x 2 = 4).

10.332 Capital Costs of Repair Alternatives

Capital costs of repair alternatives represent the initial construction or total implementation cost of each alternative. These costs are critical and must be accurate because they represent the "first" cost or the amount of money needed *NOW* if a particular alternative is selected. They include initial construction, labor, equipment, material and right-of-way costs. Capital costs do not include operation and maintenance costs.

10.334 Setting Priorities

Each utility must develop a systematic way to reach a decision on which sewer stretches of the system will be rehabilitated or replaced. The setting of priorities will also include selection of the rehabilitation method to be used.

Usually there are four possible courses of action:

1. Maintain,

2. Rehabilitate,
3. Relieve, and
4. Replace.

The normal process involves the quantitative evaluation of the following factors:

1. Performance of sewers,
2. Sewer capacity,
3. Consequence of failure,
4. Sewer condition, and
5. Costs.

All of these factors are used to set the rehabilitation program limits. Changes in conditions and funding constantly result in priority changes and program limits.

10.35 Cost-Effectiveness Analysis

When reviewing the I/I aspects of a sewer system, a cost-effectiveness analysis should be undertaken to establish the following cost considerations:

1. Survey and rehabilitation costs,
2. Construction and capital costs, and
3. Operation and maintenance costs.

These considerations are used to determine what percentage of the total rainfall-induced I/I can be eliminated at a reasonable cost.

A comparison of the cost to transport and treat the rainfall-induced I/I with the cost to eliminate it will yield the most cost-effective solution. A graph can be constructed with a plot of the transportation and treatment costs. Also, the rehabilitation cost curve can be plotted on the same graph. By combining two curves a composite cost curve can be developed which shows a minimum cost point. This point indicates the maximum I/I that can be removed cost-effectively (Figure 10.14).

When assessing the cost-effectiveness of structural rehabilitation, it is best to use *LIFE-CYCLE COSTING*[3] since the total project cost is calculated over the full life of the project. Various methods such as repairs, replacement and rehabilitation can be compared effectively because the method includes initial cost, annual maintenance costs and replacement costs. All costs are converted to a present worth in a base year. To compare present values of a project properly, a common base year, planning period and interest rate must be used. As a rule of thumb, 20 years is used frequently as a planning period. Replacement of pipe usually is expected to last 50 to 100 years. Since the normal planning period is only 20 years, the pipe will have a salvage value which must be considered.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 292.

10.3A List the four distinct courses of action that a utility may take with regard to a sewer system.

10.3B To determine the appropriate course of action to take regarding a sewer system, a utility should perform a quantitative evaluation of what factors?

10.3C What costs should be considered when evaluating the cost effectiveness of an I/I rehabilitation program?

10.4 METHODS OF REHABILITATION

10.41 Excavate and Replace (Figures 10.16, 10.17 and 10.18)

The oldest and most common method of sewer rehabilitation has been excavation and replacement. This method results in the correction of I/I problems as well as the correction of structural problems. In many cases, this method has remained popular because operators were simply unfamiliar with newer, more effective methods. Excavation and replacement is sometimes the only method that can be used because of the severity of the structural deterioration of the pipe. In other cases the severe misalignment of the pipe will not allow other techniques to be used.

Pipeline replacement results in:

1. The correction of misalignment of pipe,
2. Increase in the hydraulic capacity,
3. Repair of improper service connections,
4. Elimination of direct sources of storm water entry, and
5. Removal of incidental I/I sources.

This method should be considered as an option on every rehabilitation project to increase the bid competition. Only in a case where disruption due to the replacement is too great would it be advisable to not include excavation and replacement as an option.

When using the excavation and replacement method, all the problems encountered with new installation of pipe are applicable, as well as several problems unique to the excavation and replacement technique.

PROBLEMS COMMON TO ALL CONSTRUCTION

1. Traffic disruption and control
2. Disruption to properties (access to and easement use)
3. Paving damage
4. Shoring requirements
5. Excavation dewatering
6. Noise
7. Restoration (paving, driveways, sidewalks, fences, landscaping)

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[3] *Life-cycle costing. An economic analysis procedure that converts all costs associated with a sewer during its useful life to a present worth or present cost in dollars.*

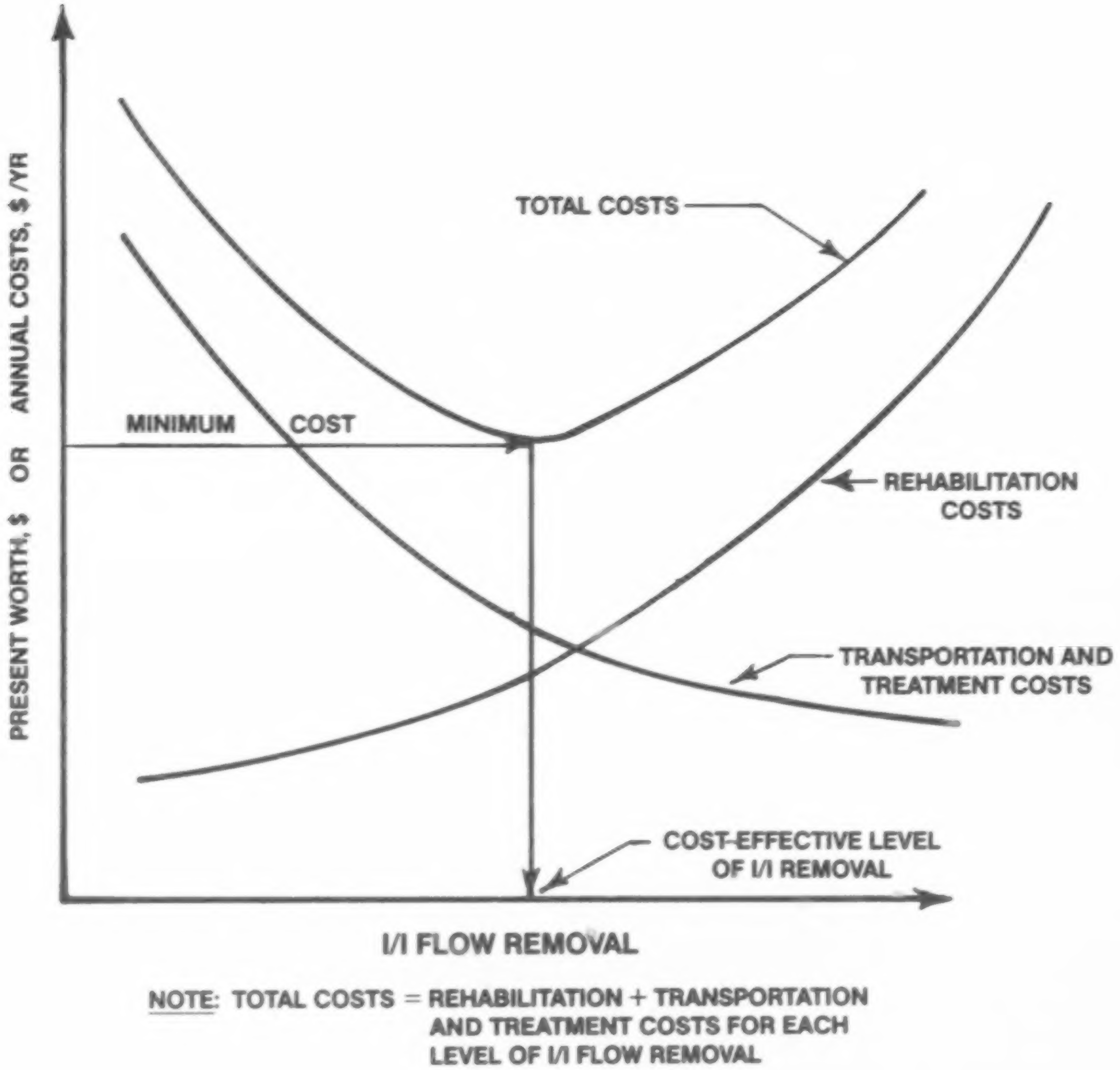


Fig. 10.14 I/I cost-effectiveness analysis

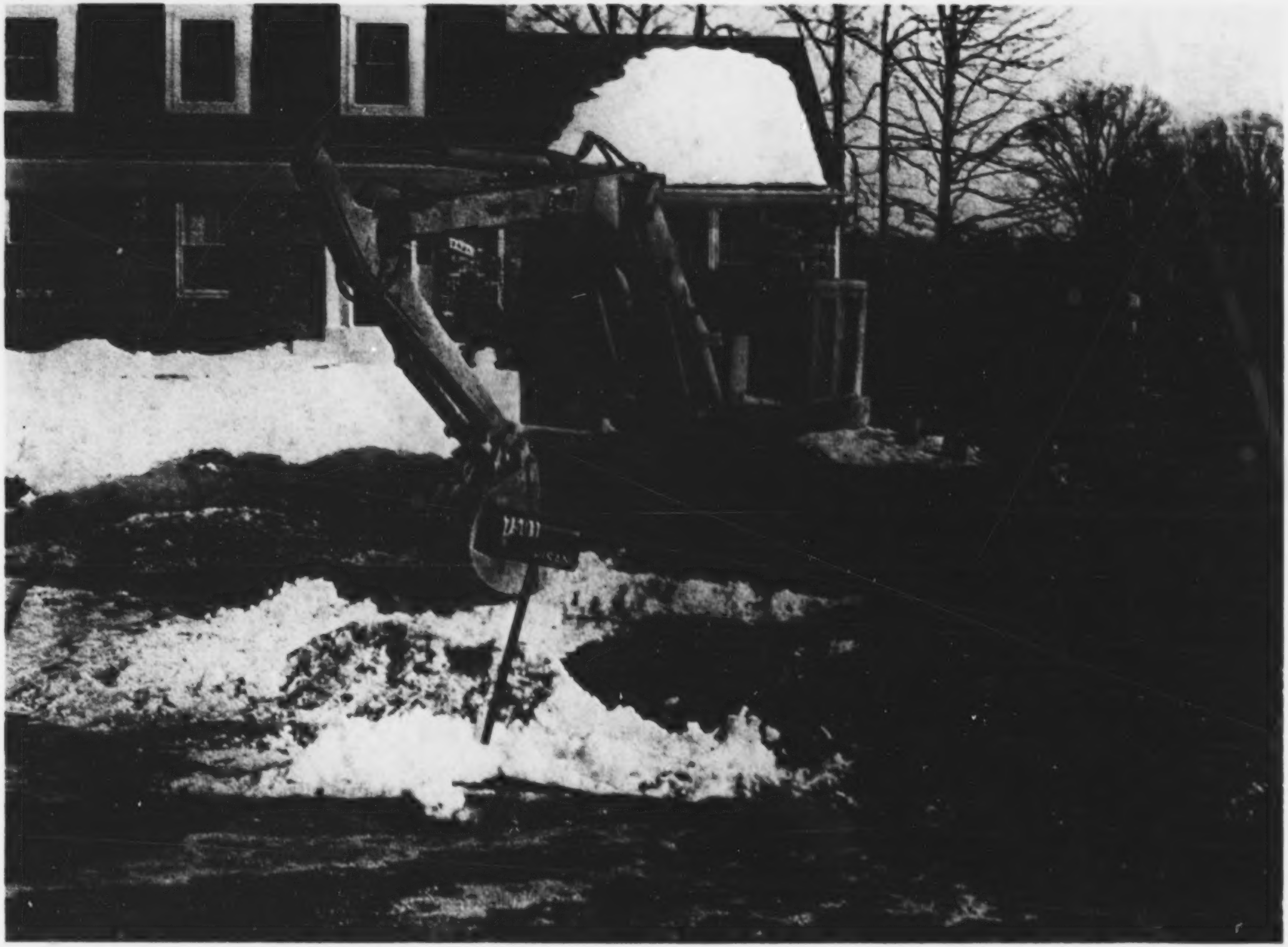


Fig. 10.16 Excavation and replacement job

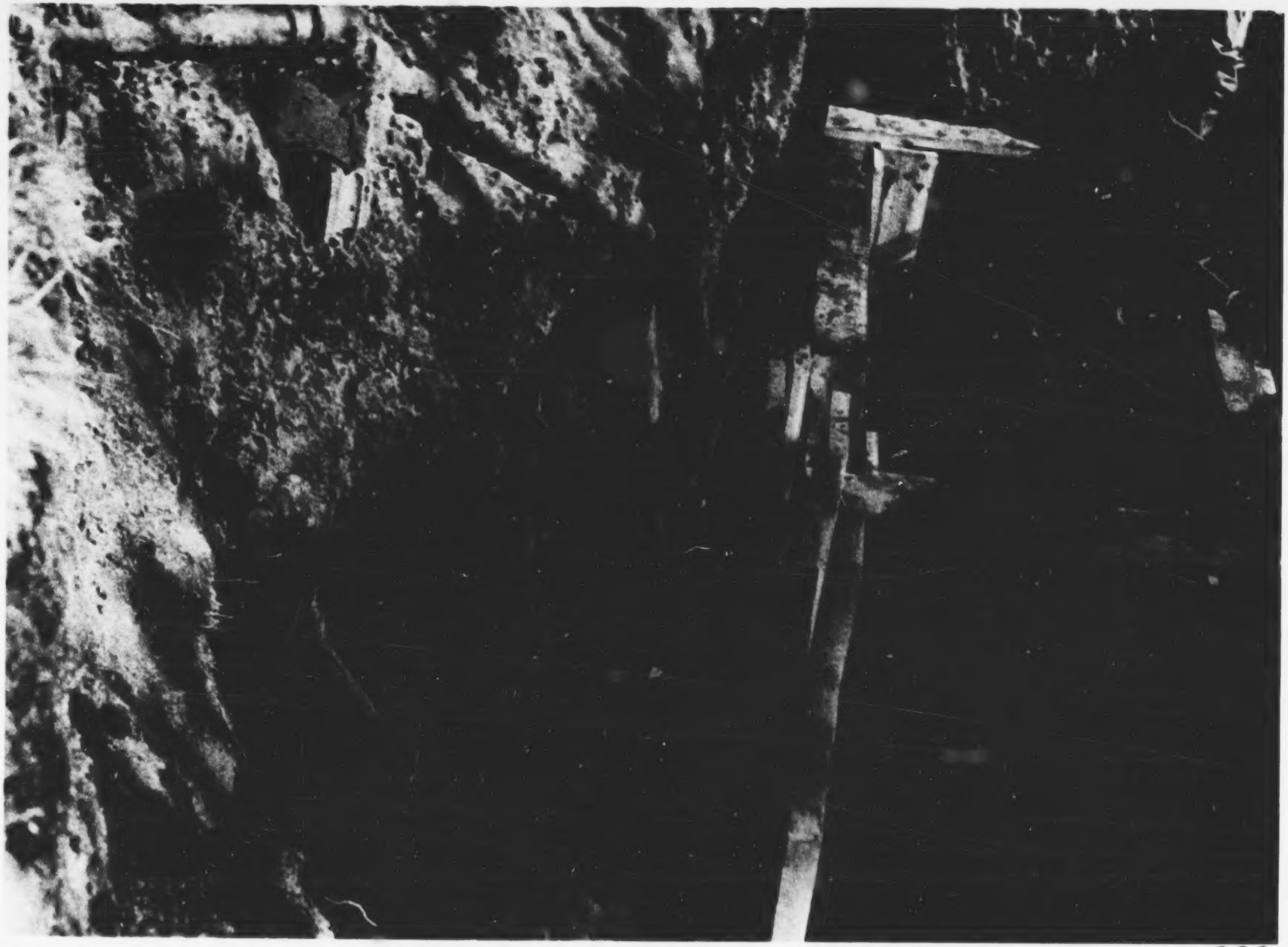


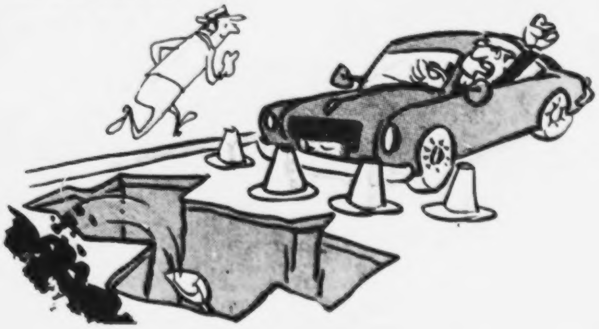
Fig. 10.17 Shoring with excavation and replacement job

Fig. 10.18 Installed pipe with excavation and replacement job

PROBLEMS UNIQUE TO EXCAVATION AND REPLACEMENT

1. Maintaining flow
2. Removal and disposal of old pipe
3. Effect on other utilities
4. Impact of shoring left in place

Although the excavation and replacement method will increase pipeline capacity and, in most cases, is the only remedy for collapsed pipe, there are several disadvantages to using this method. One is the fact that this method is normally more expensive. Also, traffic and the normal lifestyle of people living and/or working in an area are disrupted for much longer than with other methods. Finally, there is a greater danger associated with this method due to the large excavations and possible impact on other utilities. See Chapter 3, "Wastewater Collection Systems," and Chapter 7, "Underground Repair," for additional information on excavation and shoring.



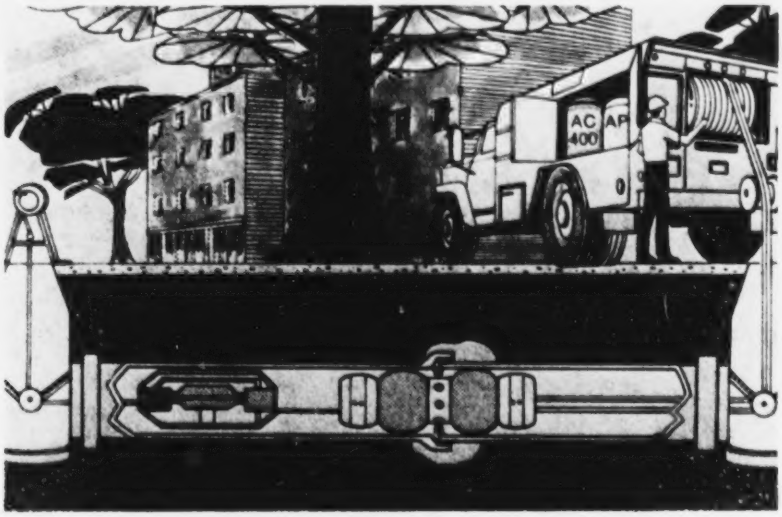
10.42 Chemical Grouting (Figure 10.19)

Chemical grouting is the most widely used method for sealing pipe joints that are leaking and for sealing circumferential cracks. The two basic groups of grouting materials are gels and foams. The foam grout forms in place as a gasket and cures to a hard consistency but retains a rubber-like flexibility. The seal takes place in the joint and there is only minimum penetration outside the pipe. The gel grout is made to penetrate outside the pipe and to infiltrate the soil surrounding the joint. The mixture cures to an impermeable condition around the joint area. The cure time for foam is significantly longer than that for gels. Foam grouts are more suitable for use if there are significant voids outside the joint area. Generally, the foam grouts are more expensive and more difficult to install.

The joints to be grouted must be clean of grease and free of root intrusion. Also, the joint must not have protrusion or significantly deteriorated areas that would interfere with the sealing of the packer. Grouting on smaller diameter pipes is accomplished by a remotely controlled packer and monitored with a closed-circuit television unit.

A typical grouting procedure is as follows:

1. Locate the joint with the closed-circuit television,
2. Pull the packer into position, centering the joint,
3. Inflate the packer sleeves until a seal is formed against the inside of the pipe,
4. Air test the joint,
5. If the joint fails the air test, pump the grout and catalyst solutions under pressure into the void between the inflated sleeves and into the soil if a gel grout is used,



NOTE: Closed-circuit television unit is on the left and packer is on the right in the pipe.

Fig. 10.19 Chemical grouting

6. Continue pumping until the gel solidifies and back-pressure is indicated, and
7. Deflate sleeves and move the packer to the next joint.
8. OPTIONAL. Sometimes low-pressure air tests are conducted on the grouted joint after curing to test the success of the grouting. Another approach is to dig up a joint and see if grout performed as expected.

In large-diameter sewers, pressure grouting is accomplished using pipe grouting rings or predrilled injection holes. To use grout sealing rings a person must manually place the ring over the joint and inflate the ring to isolate the joint. Sealing grout is pumped into the small void between the pipe wall and the ring using a hand-held probe. After the grout cures, the sealing ring is removed and used on the next joint.

The probe injection method also uses a hand-held probe but no sealing rings. Holes are drilled into or next to the joint; the number of holes depends on the length of crack or pipe size. Usually the holes are spaced about six inches apart. The grout is then pumped into the holes with the hand-held probe.

The service life of grout is a very important consideration. Acrylamide grouts have been used successfully since the 1950's. Polyurethane foam has been used since the early 1970's. Urethane gels have only been used since 1980. Manufacturers are always trying to develop better chemical grouts.

10.43 Shotcrete

Shotcrete is sometimes referred to as gunite and is a mixture of sand, cement and water applied by air pressure. The sand and cement are transported through a hose to a nozzle and are then mixed with water in a mixing chamber. Cement by hydration takes place as the material leaves the chamber and is shot into place by the air pressure. Normally, some type of cage reinforcing is placed inside the pipe to form a new wall. This method normally is used only in pipes with a diameter of 36 inches or more because entry of a person is required. This method requires diversion of all flow in the pipeline. Major structural problems can be handled by this method.

A typical installation would be as follows:

1. Remove offsets and protrusions to allow uniformly thick coating,
2. Round off all edges,
3. Insert reinforcing steel,
4. Dampen surfaces,
5. Apply shotcrete behind the reinforcement (only through one layer of steel) and a minimum of two inches over the steel,
6. Finish the surface, if desired. Surface can be left natural, broomed, floated or troweled,
7. Cure for at least 24 hours maintaining continuously moist conditions, and
8. Complete final curing. The total duration of curing is seven days during which the shotcrete must be maintained moist and at a minimum temperature of 40°F.

The advantages of using shotcrete are rehabilitation without excavation, restoration of original pipe strength and this method can be used safely when other techniques cannot. Some disadvantages are complete diversion of flow, long curing time and some reduction in the hydraulic capacity.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 292.

10.4A What is the oldest and most common method of sewer rehabilitation?

10.4B What are the disadvantages of sewer rehabilitation by excavation and replacement?

10.4C What is the most common method of sealing leaking pipe joints and circumferential cracks?

10.4D How can the success of chemical grouting be tested?

10.4E What is shotcrete?

10.44 Insituform

10.441 Description of Process

This method is relatively new and consists of the installation of a new pipe within the old pipe without excavation. Essentially, the process involves the use of a polyester-fiber felt tube, lined on one side with polyurethane and fully impregnated with a liquid thermal setting resin. The actual installation is performed by contractors, but agency personnel are often used to clean the sewer in advance and perform TV inspection before and after the job.

10.442 Preliminary Work

The sewer must be cleaned prior to installation of the Insituform line. This phase is essential since the liner is inverted into the pipe and not simply pulled into place. The *INVERSION*[4] process causes the liner to unfold from within, resulting in no relative movement between the liner surface and the pipe surface. Thus, any material or deposits on the pipe wall will be sealed (encapsulated) between the old pipe and the new liner. A loss in cross-sectional area due to encapsulation could result in loss of structural strength. The loss of structural strength results from not having a perfect circle which causes a loss in structural hoop strength. A loss in cross-sectional area will also result in a loss of flow capacity.

10.443 Basic Equipment and Materials

The basic items required for a typical Insituform installation are described in the following paragraphs.

- The inversion platform is a construction-type sectional scaffolding (Figure 10.20) erected over the point of insertion. The platform supports the inversion tube, worker, liner bag and recirculation hose during the inversion phase of the installation. The height of the platform is governed by the required head for inversion and the depth of the sewer.

- The inversion tube (Figure 10.21) consists of a reinforced polyester tube of sufficient diameter and length to allow the liner to pass from the top of the inversion platform to a steel inversion elbow located in the invert of the sewer.

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[4] *Inversion. An Insituform process in which the insitu tube or liner is turned inside out (inverted) during the installation of the liner.*

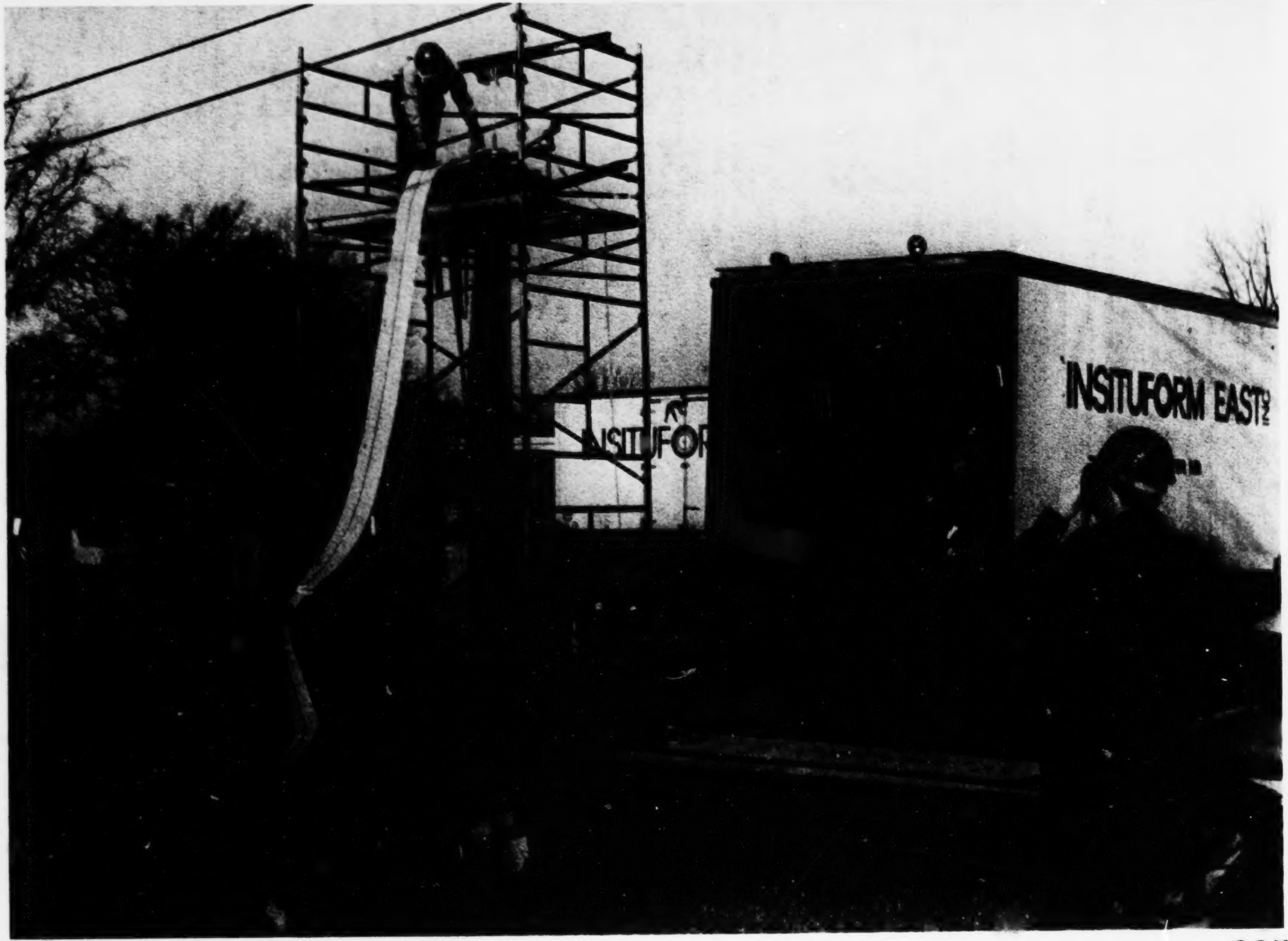
INSITUFORM EAST
INSITUFOR

Fig. 10.20 Scaffolding over point of inversion

Fig. 10.21 Inversion tube

Fig. 10.22 Inversion elbow

The top of the inversion tube is held open by means of a steel ring to which it is attached. This steel ring is also used to support the inversion tube which hangs from the inversion platform on cross-members of the scaffolding.

- The inversion elbow (Figure 10.22) is a prefabricated, 90° steel elbow of the appropriate diameter for the sewer being lined. The inversion elbow is attached to the bottom end of the inversion tube by means of stainless steel strapping. The Insituform liner is attached to the other end of the elbow by stainless steel straps.

- The portable mixer is a drum-type mixer used to mix the appropriate catalyst with the *NON-PROMOTED*[5] resin just prior to transferring the resin from the shipping barrels into the Insituform liner bag.

- A transfer pump is used to transfer the catalyzed resin from the shipping barrels into the liner bag for complete impregnation of the felt.

- The vacuum pump is used to evacuate the air from the Insituform liner bag prior to pumping the resin into the bag. This enhances the penetration of resin into the felt. Because a partial vacuum within the bag is essential to this process, the polyethylene bag covering must be entirely free of pinholes.

- Wet down conveyor system is a three-level conveyor system through which the Insituform liner and resin are passed to insure even distribution of the resin material throughout the entire bag length. Doctor or squeeze rollers are used on the top end of the conveyor to insure the proper resin saturation throughout the bag material

- Lay-flat hose (Figure 10.23) is a high-pressure hose used to circulate hot water to the far end of the liner during the curing process; it must be able to withstand the very high temperature at which the water is being recirculated.

- Hold back rope (Figure 10.24) is a rope used to control the rate of inversion after the bag is halfway inverted; if the liner inverts too swiftly, the water head may be lost in the inversion tube creating air pockets in the liner. The rope is attached to the end of the bag away from the point of inversion by means of tape and wire; it is also used to help hold back the far end of the bag when it arrives at the desired end of the inversion run by means of tape and wire.

- Water supply line (Figure 10.25) is the line used to supply the water to the inversion tube; most of the time it is connected to a nearby fire hydrant.

- The water control valve is a valve located at the top of the inversion platform to control the height of the inversion head and thereby the rate of insertion. It is extremely important that the inversion head be maintained at a static level throughout insertion. The constant static level produces an even or constant speed of insertion which results in a constant thickness.

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[5] ***Promoted.** The mixture of resin and catalyst ready to have heat applied to cause (promote) curing in place.*

Fig. 10.23 Lay-flat hose

- A circulating pump is used to circulate the water from the inversion tube to the heat exchanger and then through the lay-flat hose to the far end of sewer section being relined.

- The boiler and heat exchanger unit (Figure 10.26) is the source of heat used for bringing the water used in the inversion process up to the curing temperature of the thermostating resin.

Insitucutter (Figure 10.27) is a patented device which allows the remote operation of a cutter as it is pulled through the relined sewer. The device is positioned and controlled by an operator who is watching a television monitor through a three-dimensional control system. It enables the operator to cut out lining material in the areas defined as service taps. The television monitor shows a picture received from the internal inspection camera located within the sewer just ahead of the cutter and in reverse position.

- Thermocouples (Figure 10.28) are temperature-sensing devices placed between the liner material and the sewer wall to read the temperature during the cure and post-cure periods; these give accurate indications of the cure status of the material.

- Polyurethane-coated, polyester-fiber felt liner (Figure 10.29) is the liner bag which is inserted into the sewer to be lined. This liner is made of densely woven polyester fiber, and can vary in thickness from three to 18 millimeters in the prelining state. The liner is most commonly made of multiple layers of fiber of three millimeters each to give the desired total thickness. The primary function of the felt is to act as a medium to hold the resin prior to curing. Each layer is individually sewn into a long cylindrical tube of the proper length and diameter for the proposed lining application. Liners can be custom-designed and constructed for perfect fit. A polyurethane film is applied to the outer surface of the outer layer of material only. Its purpose in the technique is multifold, as it not only provides an air-tight membrane to enable a vacuum to be drawn on the bag during resin impregnation, but also enables the circulation of curing water throughout the liner as well as providing a smooth-flow surface for the ultimate bore.

- Polyester resin is the thermal setting resin used to impregnate the polyester-fiber felt liner. This material forms the actual smooth, resistant structure within the original conduit. The resin is of the isophthalic-acid-based-polyester

Fig. 10.24 Hold back rope

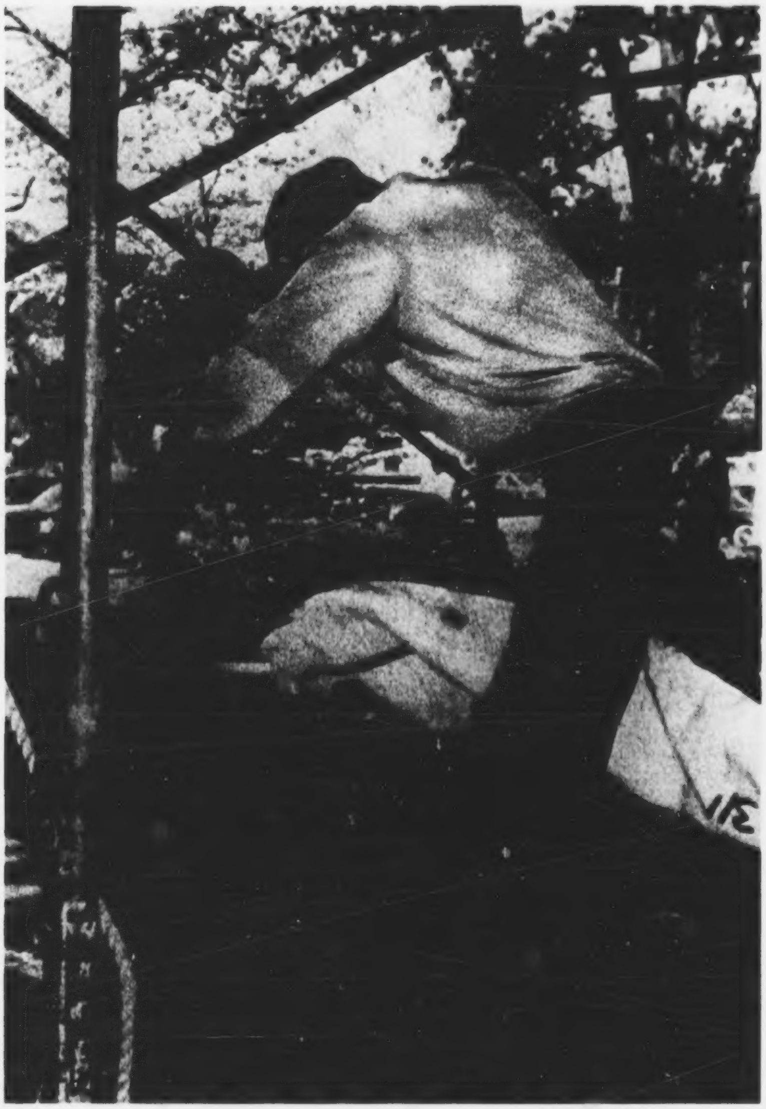

Fig. 10.25 Water supply

thermosetting type and is shipped to the job site non-catalyzed. The resin may contain certain additives to obtain special characteristics required for each application.

- Catalyst is a chemical compound such as percadox which is added to the resin to control curing temperature, life and hardness. After the catalyst is added to the resin, the resin is considered to be in the promoted or reactive state.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 292.

10.4F What is Insituform?

10.4G List the materials and major pieces of equipment required for a typical Insituform installation.

10.4H What is the purpose of the Insitucutter?

10.444 Installation Procedure

After the preparatory cleaning is completed, the internal inspection and evaluation team makes an inspection of the line to ascertain that the cleaning is complete and also to record on a TV log the location of all line deficiencies and service connections. In addition to the TV log, the line is video taped. The flow in the sewer must be diverted or stopped before the liner can be inserted into the sewer.

As soon as the internal inspection crew completes their work and determines that the line is ready for lining, the installation crew starts erecting the inversion platform. This crew is responsible for the actual inversion and curing of the liner as detailed on the following pages.

After the line is installed, cured and cooled down, the services are reinstated by the crew using the Insitucutter. This crew also performs a post-Insituform internal inspection including the video taping of the Insituformed line.

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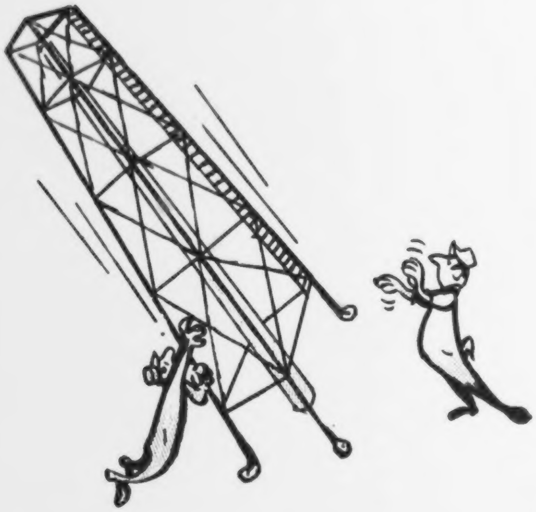
Fig. 10.26 Boiler and heat exchanger

The Insituform installation team is supported with the following equipment; sewer cleaning equipment (high-pressure water jet, bucket machines), a twenty-six foot truck equipped with boiler/heat exchanger and circulating pump, a twenty-six foot materials truck and an internal inspection van.

The wet out crew is equipped with a semi-trailer truck containing a three-tiered conveyor system and appurtenances for mixing and transferring the resin to the liner bag for felt saturation. In addition to the semi-trailer truck, the wet out crew has tarps used to make sunshades so that all resin handling can be performed out of direct sunlight.

If the pre-Insituform internal inspection indicates the sewer is sufficiently clean and free of projecting service pipes, the actual lining procedure can begin.

One of the first steps in the Insituform lining technique is the erection of the inversion platform. This platform is erected over the point of insertion of the liner into the sewer being lined, usually over a manhole.



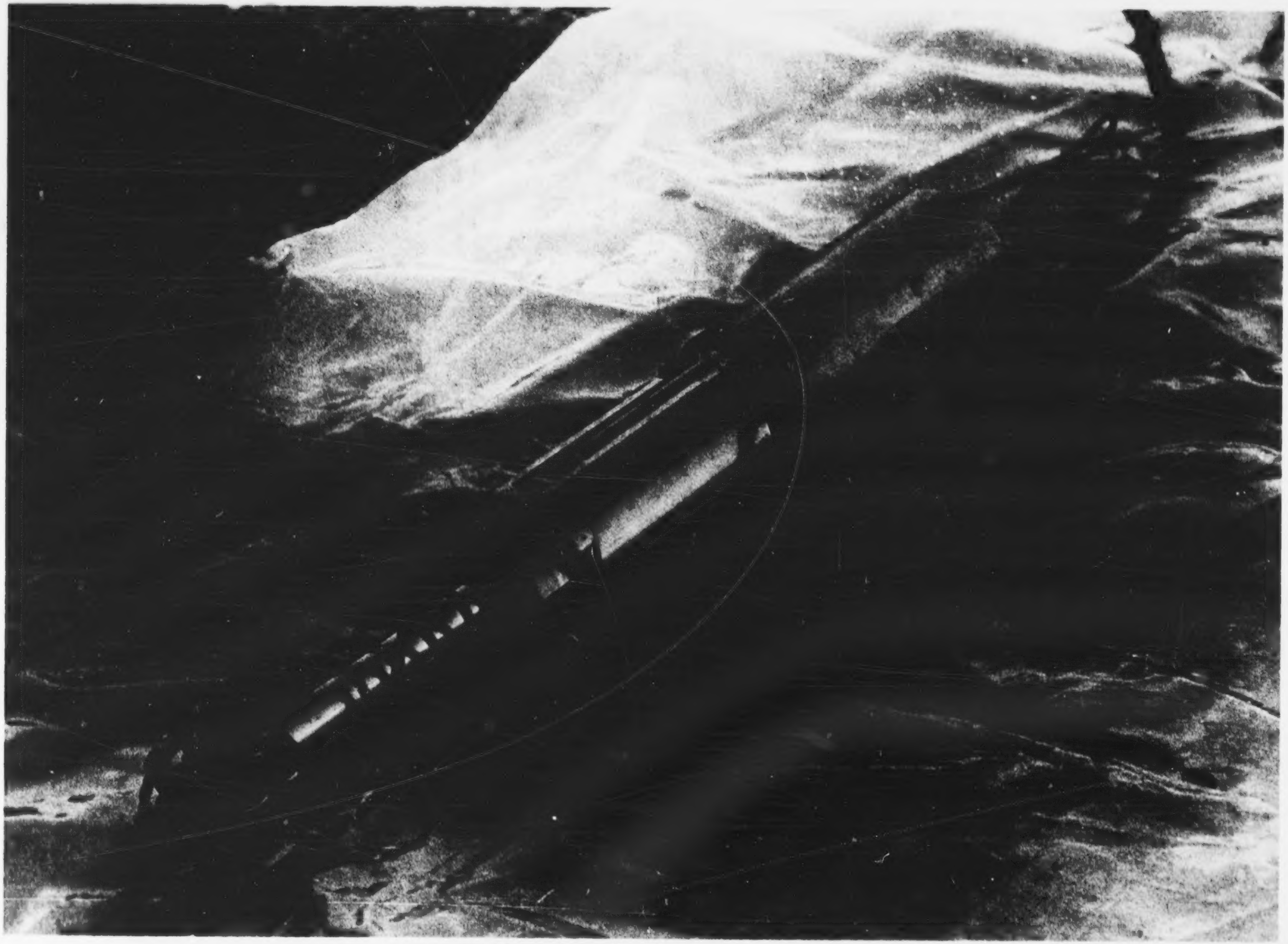


Fig. 10.27 Insitucutter

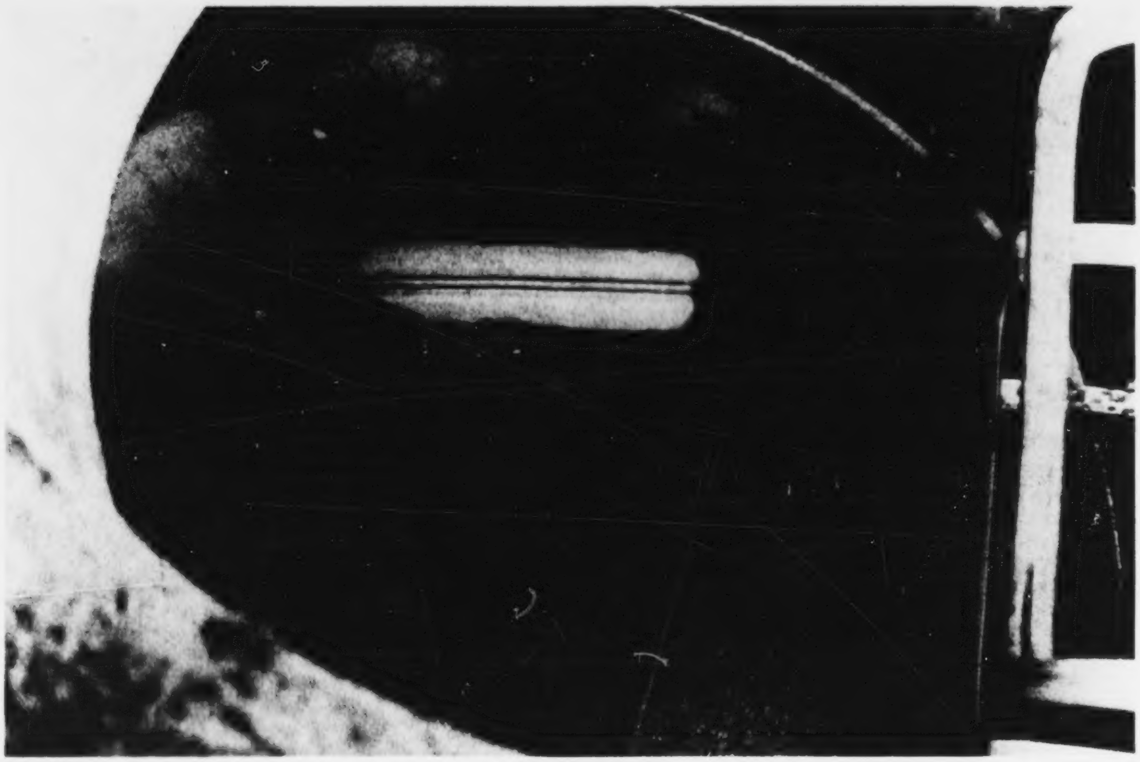


Fig. 10.28 Thermocouple attached to line

The platform is constructed of structural steel tubing using standard scaffolding frames and accessories. The scaffold height (Figure 10.30) varies with the depth below grade and the diameter of the sewer being lined as well as the thickness of the liner. The inversion heads may vary from a maximum of 38 feet (11.5 m) on a six-millimeter thick, 8-inch (20 cm) diameter bag to as little as 12 feet (3.6 m) on a nine-millimeter thick 60 cm diameter bag. The larger the diameter, the smaller the head needed for the inversion. Five to six feet (1.5 m to 2 m) below the top of the scaffold, a walk platform is installed for the workers to stand on during the inversion. Eighteen inches (46 cm) below the top of the scaffolding an adjustable inversion tube support system is installed; this support system sustains the steel rings at the top of the insertion tube. At the very top of the scaffold a capstan is positioned to act as a pulley for the bag line or hold back rope.

Care must be taken when erecting the inversion platform to be sure that the feet of the scaffold legs are on good firm ground and that the scaffold is level in all directions. Some minimal excavation or footing construction may be necessary to provide the desired degree of safety.

At the same time the inversion platform is being erected, the liner bag is being prepared for insertion by a crew working at a convenient location, usually not at the job site. There are several steps to be taken in this preparation phase. One of the first and on-going procedures throughout the entire installation is the visual inspection of the bag for any obvious flaws such as pin holes or tears in the polyethylene coating. These defects may have been caused in manufacturing the bag, although flaws of this type would most likely have been detected earlier during quality control by the manufacturer. Faults also may have occurred as a result of shipping or job site handling. If there is a defect in the liner, it is much better to detect it before the liner is installed in the sewer than to realize that the recirculating curing water is leaking.

After the liner is unpacked from its shipping container, a vacuum pump is attached to the bag to evacuate the entrapped air from the felt-liner material. This, in itself, gives a test as to the soundness of the liner since in a damaged bag, it would be impossible to draw and maintain a vacuum within the system.

While the air is being evacuated from the liner, the resin is being prepared by other workers. As mentioned earlier, the resin is shipped to the job site in drums. The resin is stored in the non-promoted state until just prior to use; it is much more stable and has a longer shelf life in the non-promoted condition.

Resin is generally shipped to the project site in drums with removable lids to facilitate mixing and transfer. The lids are removed from the drums and the prescribed amounts of catalysts are added and the ingredients thoroughly mixed with flash mixers. The lids are then replaced on the drums to await transfer of the resin into the liner bag. Care should be taken to keep the resin material away from direct exposure to sunlight; ultraviolet rays tend to deteriorate the composition of the material. Prolonged exposure in the presence of heat can possibly cause a thermosetting reaction. The resin may be kept in this state for up to 48 hours providing it is out of direct sunlight and at a temperature below 40°F (4°C). A refrigerated truck may be needed to maintain this temperature level.

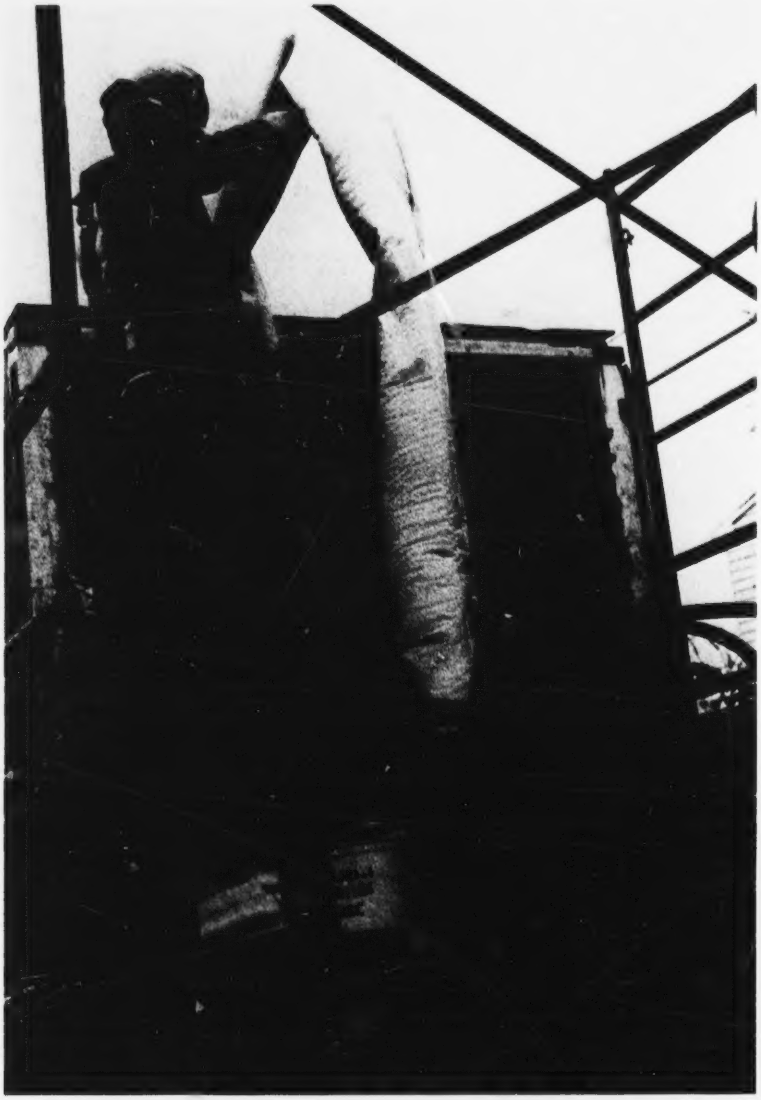


Fig. 10.29 Polyrethane-coated, polyester-fiber felt liner

The quantity of resin used for each installation should be equal by volume to 110 to 115 percent of the volume of felt in the liner bag. Resin material must be liberally spread throughout the liner bag, replacing all the air in the Insituform. Many times the activated resin contains a dye so that the spread of material throughout the bag can be documented. An air pocket in the liner devoid of resin will not cure and therefore a soft spot in the finished product will result.

The quantity and type of catalyst are determined based upon the proposed curing conditions as well as the recommendations of the resin manufacturer.

When the desired level of vacuum (5 to 8 pounds per square inch) is reached in the liner bag, it is ready to receive the catalyzed or promoted resin. The transfer of resin to the liner is accomplished by the use of a hydraulic transfer pump. The pump suction is placed in each drum and the

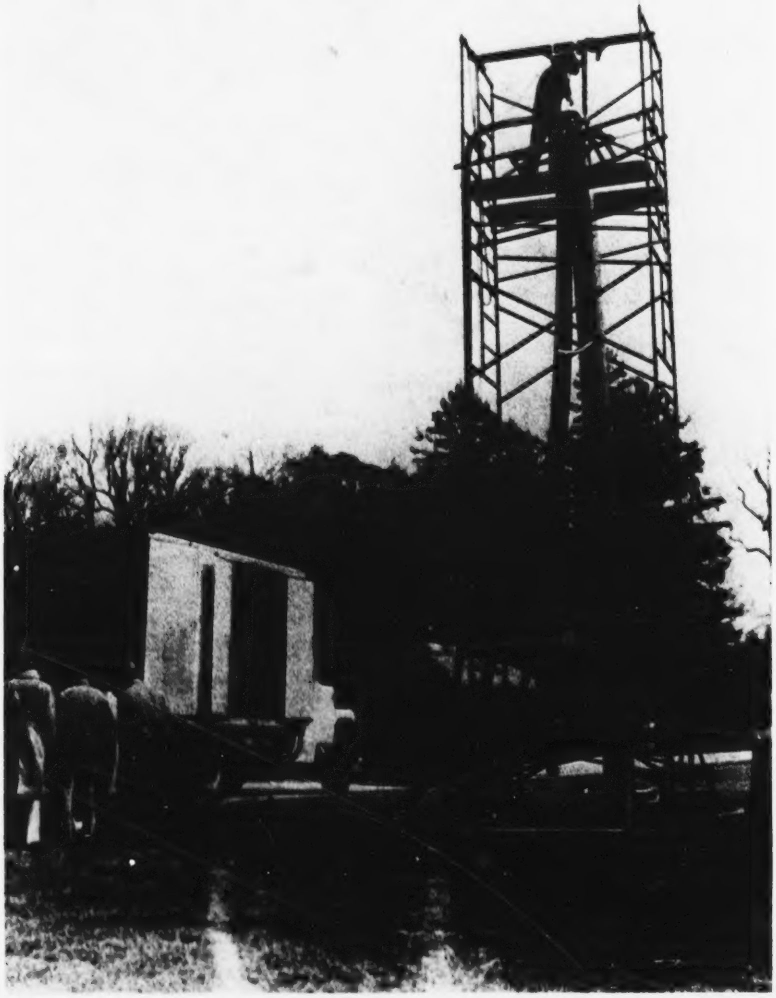


Fig. 10.30 High scaffolding necessary for inversion

contents of the drum are pumped to the line opposite the end of the liner to which the vacuum pump is attached. After all the promoted resin has been transferred to the liner, the bag is resealed at the ends.

The next step in the preparation of the liner bag is the saturation of the liner felt. An even and thorough saturation of the liner is very important to assure uniform strength and cure of the line when in place. To assure the even distribution of resin throughout the line, it is passed over a three-level conveyor system. This variable-speed system delivers the liner bag to the squeeze rollers at the proper speed to assure complete saturation of the liner felts. The doctor rolls are preset at the proper thickness to allow just the right amount of resin to pass to assure an even distribution throughout the length of the liner. The process of saturating the liner felt with resin is referred to as the "Wet Out."

For reasons previously stated, the saturated liner should be kept out of direct sunlight and at or below 40°F (4°C) during transportation and storage. The "Wet-Out" should not occur in excess of twenty-four hours before the estimated installation time.

A conventional fire hose is used to supply the water from the fire hydrant to the top of the inversion platform. The end of the hose at the top of the inversion platform is equipped with a gate valve to control the water supply rate in order to maintain a constant head.

After the inversion platform, inversion tube, and supply hose are in place, the crew is ready for the liner bag. The wetted-out liner bag arrives in a refrigerated truck, the bag being laid fire hose style in the controlled environment. Upon reaching the site, one end of the bag is immediately cut off and folded to make a triangular point and taped with duct tape, in order to facilitate passing the bag through the inversion tube. The bag is shipped flat in order to pass the liner bag through the inversion tube during insertion. The bag must be folded as it comes off the truck by the installation crew.

Prior to inserting the end of the liner bag into the inversion tube, the portion of inversion tube and inversion shoe previously within the inversion manhole are removed to an above-ground position to facilitate the attaching of the liner bag to the inversion shoe. The liner bag end is next passed over a roller conveyor to the top of the inversion platform and down the inversion tube until about fifteen centimeters of the pointed end of the liner bag extends out of the inversion shoe. The liner bag, however, is still not in position to be attached to the inversion shoe. To clarify the system used, remember that the bag is shipped with the polyethylene coating on the outside and that when the liner bag is inverted into the sewer, the polyethylene coating becomes the inside of the liner bag; actually, as the word inversion implies, the liner bag is turned inside out during the installation of the liner. The duct tape is removed from the pointed end and outer layer of polyethylene-covered felt folded back over the inversion shoe (Figure 10.31). Next, a piece of stainless steel banding is tightened over the bag material, firmly attaching it to the inversion shoe. The under layer of felt is then folded back over the shoe and firmly anchored to the shoe.

The proper banding of the liner bag to the inversion shoe is critical to the work. Should the bag come loose from the shoe or a leak develop at the interface, the inversion would have to be stopped because curing could not proceed. If the problem could not be corrected quickly, the entire insertion might have to be scrapped; this most likely would result in the loss of the liner bag, resin and all preparatory work.

After it is established that the liner bag has been properly attached to the inversion shoe, the inversion tube and inversion shoe are again lowered into position in the manhole for inversion, and wood thrust blocking is installed to brace the shoe. Before starting the inversion process, a frame backstop is installed in the far manhole to assure the stopping position of the liner back.

The water is then turned on, and the inversion tube is slowly filled to the desired inversion head. The bag is restrained until the desired head is reached by the workers on the inversion platform and in the truck. The liner bag is then allowed to slowly move out of the inversion shoe and into the sewer itself. As it slowly enters the sewer, a thermocouple is placed between the liner bag and the sewer pipe to measure temperatures in this critical location. Proper alignment of the liner bag into the sewer at the start of the inversion is checked very closely by the installation crew.

The supply valve on the water line is carefully controlled to maintain the hydraulic head as the liner is allowed to slowly move (report) out into the water. This process continues until the end of the liner bag in the truck is within approximately ten feet (three meters) of the top of the inversion tube. At this point, the inversion halts, the liner is now half way into the sewer being lined. The remaining half runs from the half-way point back down the line to the inversion tube.

A hold back rope is then wrapped around the capstan at the top of the platform, attached to the end of the liner bag. This rope is used to control the rate of inversion by holding back the liner bag; should the bag be allowed to proceed unimpeded, it would very possibly move out at such a high speed that a constant water head could not be maintained. Simultaneously with the connection of the hold back rope, a lay-flat hose is also attached to the end of the liner bag. The purpose for the lay-flat hose is to carry the heated water from the heat exchanger unit to the far end of the liner bag during the curing process.

A more even cure rate can be obtained by allowing a portion of the heated water to be released along the entire length of the lay-flat hose; this is done by providing orifices along the length of the lay-flat hose.

After the lay-flat hose and hold back rope are secured to the bag end, the inversion continues. As the liner bag approaches the downstream manhole, a second thermocouple is placed between the liner bag and the sewer pipe wall.

Prior to the inversion process starting, a frame backstop (Figure 10.32) was installed in the far manhole to assure the stopping position of the liner bag. The liner bag is normally allowed to enter into the far manhole before the inversion is terminated. This projection into the manhole allows the liner bag to expand and cause a slight flared end at the sewer wall intersection producing a superior seal between the sewer and the liner. At the end of the inversion the hold back rope is tied off to the capstan.

With the liner bag completely inverted, the next procedure is the curing of the thermosetting resin-saturated liner bag. The curing of the liner bag is accomplished by heating the water used to invert the liner bag to a temperature which will cause the resin to cure and harden. The temperature needed to cure the liner bag can be adjusted by the type and amount of catalyst added to the resin before wet-out; the normal cure temperature of 180°F (82°C) is used.

The heat exchanger and recirculation pump is mounted in a truck which is backed up to the inversion platform. This truck also contains a diesel-driven generator to power the electric drive motor on the recirculating pump, and to supply electricity for other lighting and power requirements. In addition to the generator, the truck contains an oil-fired water tube boiler to supply heat for the heat exchanger. A suction line is attached from the inversion tube to the recirculating pump; a second hose attaches the heat exchanger to the lay-flat hose. A complete recirculation loop is now in place taking water from the inversion tube through the heat exchanger and returning it back into the sewer line via the lay-flat hose.

After circulation is begun and it is determined that the flow distribution is proper, the boiler is fired and the heat-up begins. Water temperature at the beginning of the heat-up is 55°F (12°C). Temperature gages on the suction and discharge lines in the truck show that the temperature of the circulated water will increase rapidly as it goes through the heat exchanger and into the liner section.

Monitoring of the thermocouple temperature at the near and far manholes shows the actual increase in the temperature of the liner bag. The heat sink ability of the ground around a sewer can vary greatly with groundwater, backfill and local utility conditions, and therefore the temperature of

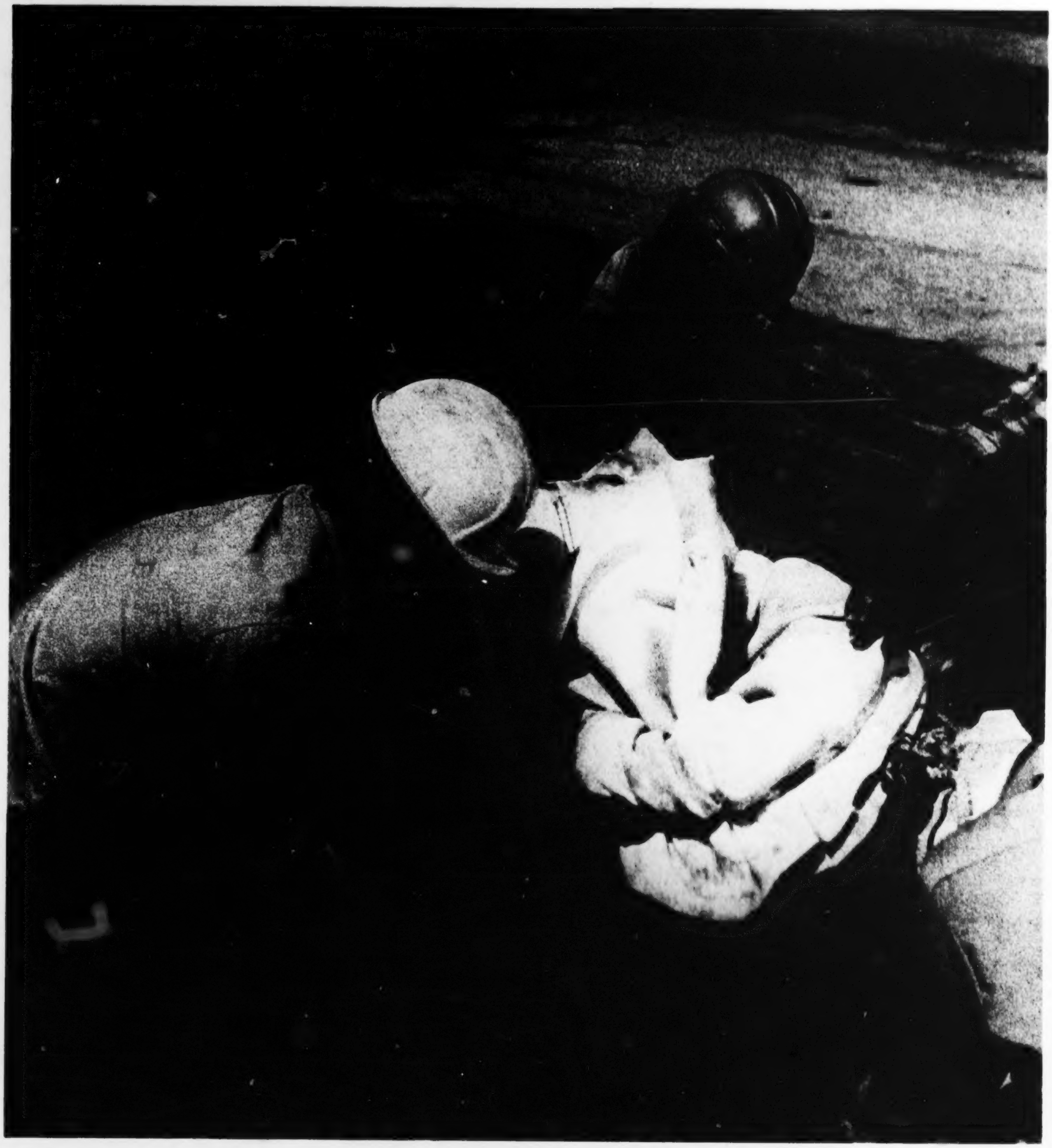


Fig. 10.31 Bonding of liner to elbow

Fig. 10.32 Frame backstop

recirculating water versus liner bag outer surface temperature may vary; hence, the temperature of the circulating water should never be used as the only criteron for determining the extent to which the process has proceeded.

Care should be taken in determining bag length as recommended by the bag manufacturer for the size, length, and proposed inversion head. The problem associated with a bag that is too short is apparent. The problems with a bag that is too long are not so apparent but are quite real. A bag that is too long means extra cost for wasted bag and resin and extra manpower to remove the uninverted cured portion of the bag. In addition to the above problems, a bag with a long uninverted section prevents the hot water in the lay-flat hose from being discharged at the end of the liner bag.

Special consideration should be given to safety factors during installation and curing. Care to protect workers, spectators, and equipment from hot water should be observed by the use of rubber wear and protective shrouds. Any time workers enter the manholes, self-contained breathing apparatus, helmets, and harnesses must be worn. Strong volatile styrene odors are created during this process to which prolonged exposure should be avoided.

If installation is made during the night to take advantage of low sewer flows, the running of equipment such as pumps, boilers, and trucks may cause some problems because of noise in residential areas. This should be evaluated when scheduling installing times and satisfactory arrangements should be made with those involved.

10.445 Reinstatement of Services

The next step is the reinstatement of the services. This portion of the sewer relining technique is unique to the Insituform procedure. It requires the remote guidance of a cutter operating within the sewer itself. The cutter is called an Insitucutter and is patented. The Insitucutter is similar to a pneumatic drill or router and is operated in conjunction with the internal inspection camera.

The camera-cutter combination are pulled in tandem through the newly lined sewer in such a way that the camera continually views the cutter. The cutter is located adjacent to the location of each service which has been previously identified and recorded during internal inspections.

In addition to the previously-recorded locations of the services, they may also be detected visually on the interior of the newly lined pipe; services appear as convex areas on the pipe wall. The operator viewing the service location positions the Insitucutter by watching a television monitor; the operator also may place a microphone in the sewer for audio reference, since there is a distinctive difference in the sound levels noted between cutting the liner material and the actual conduit material.

The Insitucutter is capable of movement in six distinct directions. The operator, by both listening and watching the monitor, then proceeds to cut out the liner material covering the service opening. Excess resin in the liner bag migrates into the service joints and forms a weld-like seal between the walls of the service pipe and the liner in the main.

Problems are created for the service connection process when water stands in the service behind the liner. When the spinning drill pierces the Insituform covering over the service to be opened, water and liner material are splashed in every direction, including on the lens of the camera, thus significantly impairing the operator's view. Should the debris become heavy, the camera-cutter assembly must be withdrawn from the line for cleaning. This situation can cause a considerable slowdown in the opening of service taps. For this reason, all customers served by the sewer should be notified in advance that water will be shut off prior to rehabilitation. This alone may not totally relieve the situation in that many times infiltration in the service line may back up behind the lining. Service connections should therefore be cut out as soon as possible after the liner has cured.

Experience has shown that the average service connection can be renewed by the Insitucutter in approximately 15 minutes. If there are many services to be renewed, it is advisable to travel the length of the lining and cut a small relief hole in each service dimple. This prevents a buildup of water from either infiltration or customer use of sanitary facilities. After all service connections have been relieved, the Insitucutter then commences to reinstate each service to full-bore opening. This procedure in most cases relieves the requirement for providing any alternative sanitary facilities.

Upon completion of the opening of the service connection, a post-Insituform internal inspection is performed. This post inspection reveals the sewer to be completely relined with a joint-free, smooth liner.

10.446 Advantages of Insituform Method

Advantages of the Insituform method are reduced cost, no excavation, completion of work in a 24-hour period, complete structural strength and total elimination of I/I into the sewer stretch. The only disadvantage to the process is the diversion of flow while the work is being accomplished and the residents being without water and sewer services for approximately 10 to 12 hours. The advantages far outweigh the short inconvenience factor.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 292.

10.4I What happens after preparatory cleaning is completed on an Insituform sewer rehabilitation job?

10.4J In the Insituform lining technique, where is the insertion platform erected?

10.4K How can a liner be tested for damages after it has been unpacked from its shipping container?

10.4L What safety precautions should be taken during the installation and curing processes of an Insituform job?

10.45 Polyethylene Pipe Lining

10.451 Why Line Sewers?

Polyethylene pipe lining (slip lining) is a repair method accomplished by inserting flexible polyethylene pipe into the existing sewer system.

Liners can be an effective method of pipe repair or reconditioning of the sewer system. Frequently liners are installed to control excessive infiltration, exfiltration and root intrusion. Selection of this method depends on whether this procedure is simpler, quicker and more economical in comparison with other techniques available to solve the problems in the sewers. Slip lining requires excavation at the points of insertion into main lines and house service connections. In general, slip lining costs less than Insituform, but the costs of excavation and traffic disruption may offset the installation advantage.

10.452 Preliminary Work

Before attempting to do any slip lining, there are some very important items to consider. Identify the area to be slip lined and carefully review available records and maps of the area. Plan the operation on a step-by-step basis.

Send to each homeowner a typewritten letter explaining why the project is necessary, what is planned and what you expect to accomplish by the operation. The letter should indicate that the homeowner could be temporarily inconvenienced during construction and also explain the benefits that will result from the completed project. Advise the homeowner of any direct costs that must be paid. Send along with this letter a form, legally prepared, for the homeowner's signature. This form provides authorization to do any and all work necessary to accomplish the job. It also guarantees that the premises will be restored to as near its original state as possible at no additional cost to the homeowner.

Take photos of the yards around each house that may be affected by the job. This provides a picture record of the appearance of the premises before the work is performed. If necessary, a comparison may easily be made when the work is completed.

Notify all of the utility companies in the area and ask them to locate and mark all of their underground lines in the area.

With closed-circuit TV or video tape, film the main line and location of each lateral, any misalinged joints and any other discrepancy which will need to be corrected before the actual lining takes place. Then mark locations on the street surface.

Conduct a physical survey to determine the amount, size and type of material needed to do the job and order the material. The list of materials should include plastic pipe for both the main line and the laterals, tee saddles, couplings of the various sizes needed and materials for the cleanouts to be installed on the lateral near the house.

10.453 Equipment

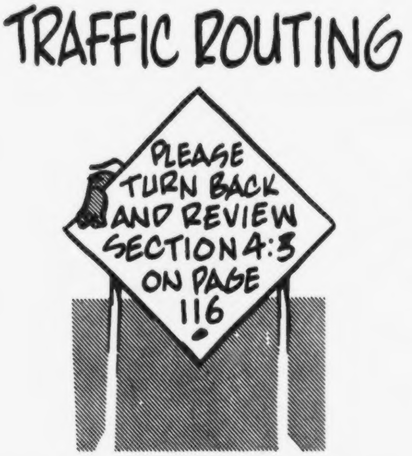
To do the job you will need a backhoe for excavating, cable winch for pulling the pipe through the main line, pneumatic equipment for pavement breaking and compacting the backfill. Also needed are dump trucks, a utility truck for transporting material and small tools, and a flat bed truck with a specially constructed rack for transporting the 40-foot lengths of pipe and plastic fittings. This truck carries on it the equipment required for fusing the plastic pipe together, a generator which provides the power needed to operate the heating elements and other electrical equipment. The generator should be capable of producing at least 2,500 watts.

Equipment needed to prepare and weld the pipe includes fusion joiner jigs and mobile carts to handle both the main line pipe and laterals, a butt fusion tool or squaring tool and heating faces (both flat and part-round) for heating the saddles. Pulling heads and tapping or coring tools are needed plus accessories to adapt to the various sizes of pipe that will be used.

10.454 Inserting Liner in Main Lines

Be sure all misalignment and other problems have been corrected before starting the lining job.

Transport all material and equipment to the job site. Hold a brief group discussion to review the operation and safety considerations. Set up cones and safety warning devices and, once a proper traffic control pattern is established, begin the actual work. (See Chapter 4, Section 4.3, "Routing Traffic Around Job Site.")


TRAFFIC ROUTING
PLEASE TURN BACK AND REVIEW SECTION 4:3 ON PAGE 116

While one crew assembles the liner, the excavating crew begins digging the pull hole at a pre-determined location. Pulling distances will vary in accordance with the job conditions. A third crew prepares the pulling equipment and pulley apparatus in the manhole into which the liner will be pulled. The pulling hole will be approximately 30 feet in length and as deep as the main line. The depth of the main line usually determines the length of the pull hole. The deeper the main line, the longer the pull hole. Once the pull hole is dug and the main line exposed, a high velocity cleaner is used to be sure the main line is clean. The main line in the pull hole is then broken and a high velocity cleaner is sent through the line to clean the pipe and at the same time pull the winch cable from the manhole to the pulling hole. At the pulling hole, attach the winch cable to the special pulling head which is welded on to the pipe liner.

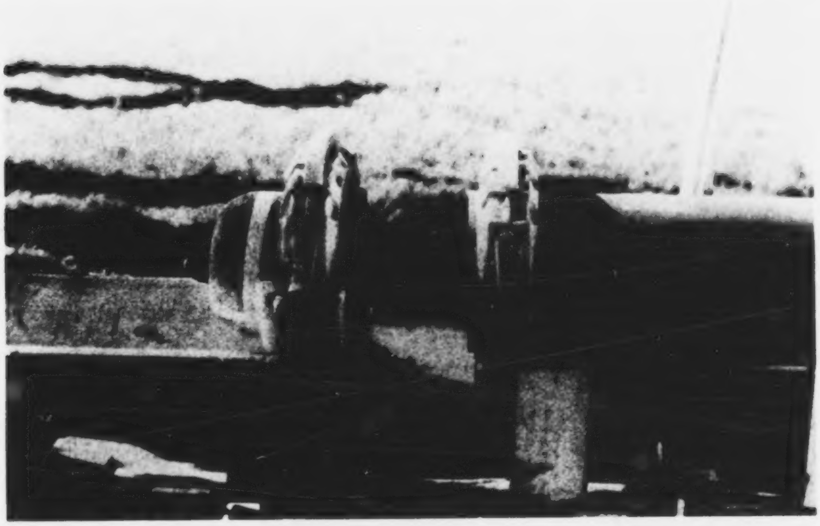
Weld together the amount of pipe for this particular pull and weld on the pulling head (Figures 10.33, 10.34 and 10.35). Use a fusion jig and mobile cart to weld the material together in the following manner. Place the two pieces of pipe to be joined into the jig and use a squaring tool to true the ends of the pipe. Once this has been accomplished, bring the heating face to the proper temperature — 500 degrees Fahrenheit (260° C). Heat both pipe ends simultaneously until a small bead begins to form, then continue to heat them for 10 seconds more. Snap off the heating face and butt the two ends together, holding them firmly for approximately one minute. Let the joint cool for at least three minutes before moving to the next joint. Tests have shown that the pipe is actually stronger where the weld has been made than at the run of the pipe.

Once the required joints of pipe have been welded together and the pulling head attached, mark the pipe with chalk or crayon at 50-foot intervals. This is a precautionary measure. If there is a pulling problem and the pipe hangs up in the line, it may be necessary to dig up the pipe. By marking at 50-foot intervals, you can easily locate the pulling head in the line. Hopefully, there will be no problems.

When all is ready (Figure 10.36), attach the cable to the pulling head with a clevis. Station an operator in the pull hole to guide the liner smoothly into the pipe. Signal the winch operator to begin the pull (Figure 10.37). Providing that there are no problems, the pull will be completed in a few minutes.

Once the pulling head comes through at the manhole where the pull is made, remove the cable. "Whip in" the pipe to take up any stretch that occurred during pulling. To do this, protect the end of the pipe with a board and then hammer on it with a sledge (Figure 10.38) until the stretch is taken up. The last step is to cut off the pulling head (to be reused later) and prepare for insertion of liner into the laterals.

Whenever there is occasion to pull the liner through a manhole, the upper half of the liner is cut away, leaving the lower half to serve as a channel in the manhole. The manhole must be sealed around the opening in the liner. Sometimes the liner is removed and a new channel bottom is installed during the sealing operation.



Pulling head ready to be welded onto pipe

Fig. 10.33 Attaching pulling head
(Courtesy of Napa Sanitation District)

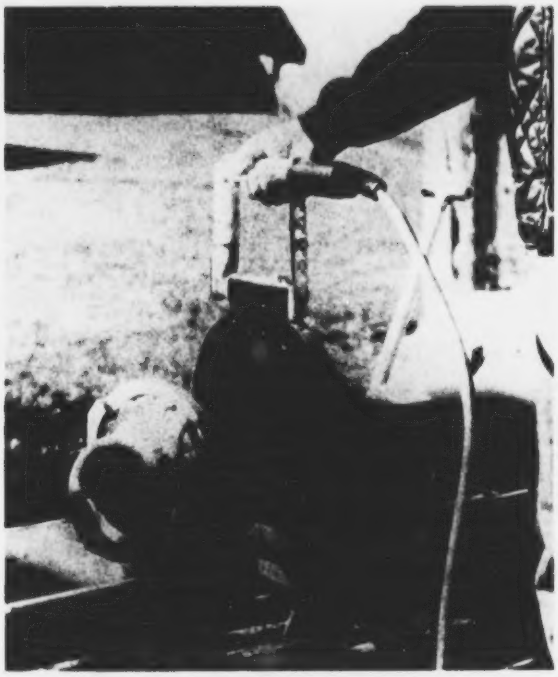


Fig. 10.34 Heating face to be applied to pulling head and pipe

(Courtesy of Napa Sanitation District)

The *ANNUALAR SPACE*[6] between the outside diameter of the plastic liner and the inside diameter of the old sewer line, in most cases, is sufficient to handle the wastewater which is introduced into the system through the old connections until the entire operation of installing new laterals has been completed.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 292.

10.4M How do liners repair or recondition a sewer system?

10.4N What information is included in a letter to homeowners explaining a slip lining project?

10.4O Why should a sewer be video taped or filmed before slip lining?

10.4P What equipment is needed to weld polyethylene pipes together?

10.4Q How many crews are recommended and what are their duties for a slip lining project?

10.4R Why should the liner be marked at 50-foot intervals before being pulled into the sewer?

10.455 Lining and Connecting Service Laterals

The methods employed in this operation will vary depending on whether the existing service lateral will be connected to the polyethylene main or if the lateral itself will be completely relined.

A substantial amount of infiltration could enter the collection system through breaks or bad joints in laterals. Determine whether the laterals need slip lining and, if so, follow the procedures outlined in the next section.

Lining Procedures

The procedures used to slip line a lateral are similar to the ones used to slip line the main line. Instead of using a pulling hole, dig a pushing hole at the main where the old service lateral made its connection (Figure 10.39). Dig another hole at the house to expose the other end of the lateral; break the connections at both ends. Fuse the desired length of pipe, as described in the previous section. Weld a nose cone to the tip of the new liner. (This will be used to insert the liner into the old pipe lateral.) Pull a swab through the old pipe to make certain it is free of grit and roots and to locate any bad obstructions.

When these preparations are complete, push the new lateral through the push hole at the main line until it is visible in the hole near the house. Align the new pipe to the main and weld a saddle in place. When the weld has cooled sufficiently, core the line to complete the connection (Figure 10.40).

Backfill the excavation at the main line. To minimize the possibility of the pipe and lateral getting out of round at this point or egg-shaping in any way, carefully pack the area beneath, alongside and over the pipe with fill sand. Then backfill the rest of the hole with a granular backfill material by carefully compacting it in lifts of one to two feet. Last, repave the surface of the street.

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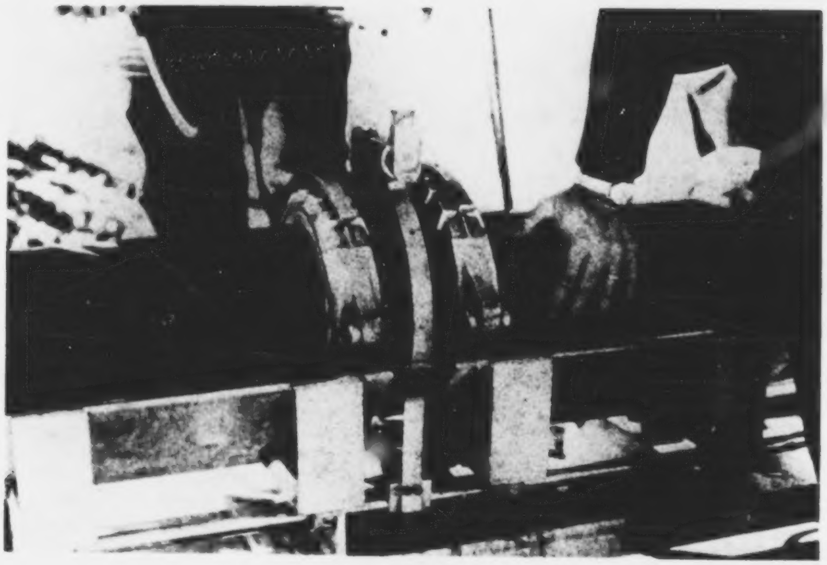
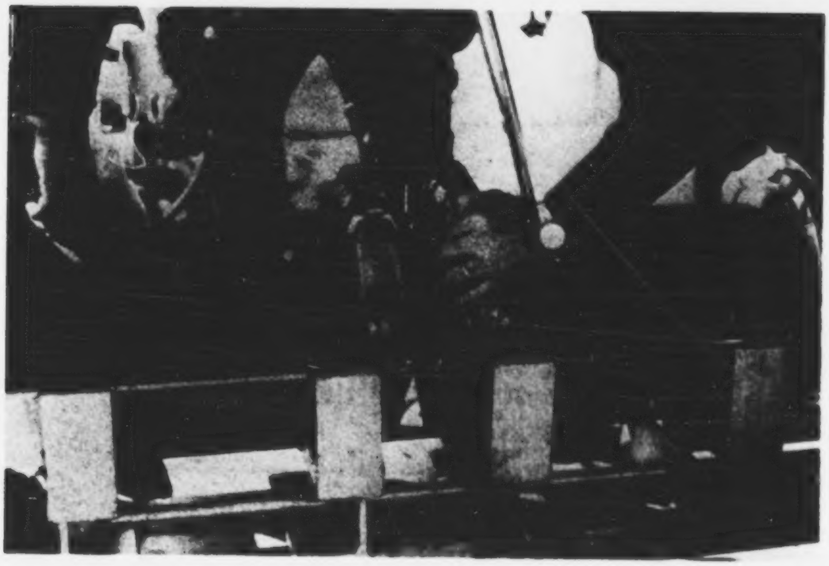
[6] *Annular space (AN-u-lure). A ring-shaped space. For example, the space between the outside of a pipe liner and the inside of a pipe.*



Heating ends of pipe



Fusing ends of pipe together

Fig. 10.35 Fusing pipe together

(Courtesy of Napa Sanitation District)

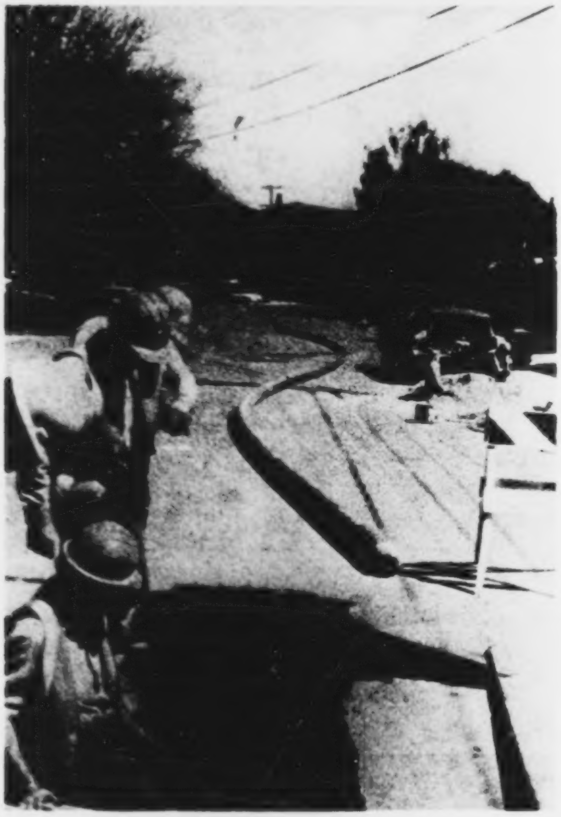


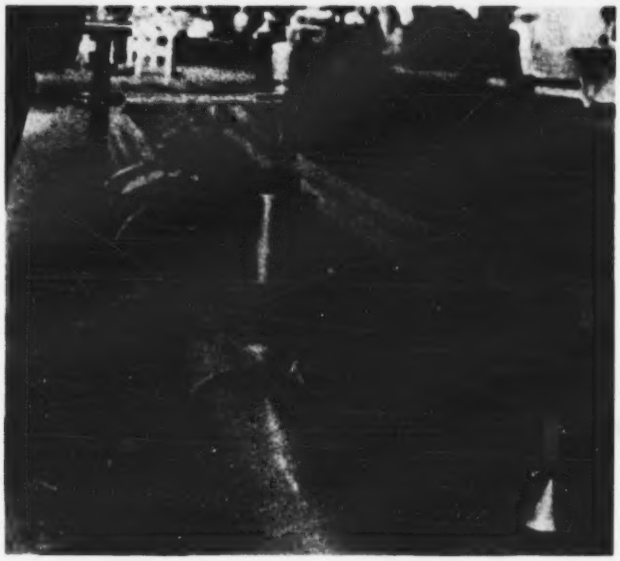
Fig. 10.36 Pipe fused together ready for pull
(Courtesy of Napa Sanitation District)

Fig. 10.37 Walking the pipe liner in
(Courtesy of Napa Sanitation District)

Fig. 10.38 "Whipping in" the pipe after pull
(Hitting end of pipe that is protected by a board with a sledge hammer)

Fig. 10.39 Street cut for service lateral
(Courtesy of Napa Sanitation District)

Inspecting the saddle



Saddle and coring tool

Fig. 10.40 Saddle for lateral
(Courtesy of Napa Sanitation District)

Installing Cleanouts

Assemble the fittings to be used for the cleanout connection to the lateral at the house. Basically, these include a 3-inch combination wye and 1/8 bends, a 3-inch to 4-inch reducer, a plastic cleanout cap, a *CHRISTY BOX*[7] which will be used as the cleanout point, and the assorted couplings needed to make the proper connections.

When all of the tools and materials are assembled to install a cleanout, cut off the nose cone attached to the new liner. Install the fittings and connect to the house plumbing. Next, install the riser. Cut the riser to the desired height, normally several inches below the ground or lawn level, and attach it to the 1/8 bend of the combo wye. Position the christy box on the riser and mortar to within one-half inch of the top of the riser. Put a plastic cap on the riser and place the lid on the christy box to complete the operation. Backfill lawn areas with loam and plant new lawns in areas which have been disturbed.

Installing Tee Saddles

There are several ways to install a saddle on the main line including the use of mortar, banding, and welding. Fusion welds provide a good seal and a strong connection and will be described in this section.

Expose the main line at the point where the tee saddle will be located. Break away and remove the old pipe leaving the plastic liner exposed. Dig a well hole large enough to allow room to work with the apparatus needed and to keep the hole free of water, if necessary. Carefully clean the pipe and sand the glossy surface. Position the saddle in the approximate place where it will be welded and "mark in" the location with a crayon. Next, place the saddle in the saddle holder and press onto the preheated heating face. When the saddle reaches the desired melting point, place it and the heating face against the pipe at the marked location. Allow both the main and saddle to heat simultaneously until they reach the desired melt. Remove the heating face from the line, snap the saddle free and press it onto the main line. When the weld has cooled sufficiently, core the main line and connect the lateral by means of a coupling.

Pack and bed the pipe with fill sand. Then finish up by backfilling and compacting the rest of the hole with granular backfill. Repair the street paving to complete the job.

10.456 Sealing the Space in the Manholes

Infiltration must be prevented from entering the system at the manhole from the space between the new liner and the existing line. Part of the pipe through the manhole is used as a channel whenever possible. The procedure for sealing is easy. Use oakum rope soaked in a urethane sealing compound or chemical grout that is activated by water. Pack the soaked oakum rope into the space between the pipe and the manhole. Carefully pack the rope tightly into the space. Finish off the work with a quick-set cement. The channels of the manhole should be properly shaped and the shelves of the manholes should be completed to give the proper pitch and finish.

The entire area is then double checked and policed to be sure that all phases of the job are complete. Once this has been accomplished, the operation is moved to the next area, set up for "slip lining" and the entire procedure is repeated.

10.457 Thank the Public

The project began with a letter and should end with a letter to each homeowner, signed by the Chairman of the Board of Directors or other appropriate official. The letter should thank homeowners for their cooperation. Good public relations at this time can be very helpful now and in the future.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 293.

10.4S When slip lining laterals, where are holes commonly dug for the liner?

10.4T Why is the space between the liner and the manhole sealed?

10.46 Other Methods

1. Polyurethane Resin Coatings. These coatings are used as corrosion-protective coating only. They have no structural value but do provide abrasion resistance, water impermeability and stand resistant to pollutants in wastewater.
2. Expandable PVC Repair Sleeves. These sleeves are used for spot repairs of cracked pipe. The system consists of six segments of Normal Impact Type 1 PVC 1120 material. These segments are joined by hinges which allow the assembly to collapse for insertion in the pipeline. The collapsed assembly is inserted into the line and pulled into position by a cable. At the repair site a remotely operated jacking device is used to expand the module into place. The jacking device is withdrawn and the repair is complete.
3. Segmented, Fiberglass-Reinforced Cement Liners and Plastic Liners. These liners are thin panels developed to rehabilitate sewers larger than 42 inches in diameter. The liners are segmented to fit the diameter required. All shapes can be accommodated. These linings provide good corrosion protection, but are not designed to provide structural support. The smooth surface provides improved hydraulic capabilities.

10.47 Service Connections

Service connections are defined as branch connections that go from the sewer main in the public way and connect to the building sewers. Each jurisdiction has varying responsibilities for portions of these service connections. Some jurisdictions are responsible for the service tap only, others are responsible only to the property line and some jurisdictions are even responsible all the way to the building on the property. These service connections can be various pipe sizes ranging from four inches to eight inches dependent on the nature of the property served. Normally, the length of the connections varies from about 10 feet to 100 feet depending on the layout of the street and the agency's responsibility.

During the past few years it has been found that a significant quantity of I/I enters the sewer system through the service connections. Each point of connection, at the top, at the property line, and at each joint in the service, is a potential location for I/I. Also, with the underground utilities crossing the services, there has been much structural damage detected in service connections.

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[7] *Christy box. A box placed over the connection between the liner and the house sewer to hold the mortar around the cleanout wye and riser in place.*

There presently exist three methods of chemically grouting service connections to eliminate I/I. They are pump the service full of grout, sewer sausage, and camera-packer. Each method uses grout as the sealant but each requires a different application technique.

GROUT
SEWER SAUSAGE

Pump Full. The sewer service is pumped full of grout from a conventional packer located in the main line sewer where the service connection is connected. As the grout is pumped into the service under pressure, the grout is forced through any open joints or cracks into the soil. The gel sets up, in the same manner as main line grouting, forming a barrier that keeps water from entering the service. The sewer service connection is then cleaned with an auger to remove the excess grout and this restores the service connection to full service.

Sewer Sausage (Figure 10.41). This is a sewer service sealing unit that requires a special packer with an inflatable tube. The tube is inserted into the service connection from the packer and then is inflated to create a sleeve inside the service connection. The packer then forces the chemical grout into the annular space between the sleeve and the service connection pipe. The pressure forces the grout out of open joints and cracks into the surrounding soil, where it sets up and provides a barrier so water cannot enter the service connection. The sleeve is deflated and retrieved into the packer. This method does not result in excess grout requiring auguring to restore the connection to full service.

Camera-Packer. A specialized miniature camera and packer are inserted into the service connection. Joints and cracks are sealed in a manner similar to the conventional method used in the main line.

Inversion lining or Insituform has been used for provide structural rehabilitation to a service connection. This method also eliminates all I/I in the portion of the connection lined by this method. This process material is similar to the main line Insituform work. One excavation point is necessary on the service connection so the Insituform liner can be inverted into the connection. A special pressure chamber is used to force the Insituform liner through the pipe. This smaller unit is used instead of the normal inversion tube because less force is required to turn the line inside out when it is only four inches in diameter. After curing the downstream end is cut out by a special cutter placed in the sewer main. The upstream end is cut out and the service connection reconnected and placed in service.

Most agencies use the standard excavation and replacement technique to replace deteriorated service connections. This method requires the greatest effort and results in the most disturbance to the area. This is the only technique available when the service connection has suffered total collapse and is in a crushed condition. The restoration costs usually result in this method being extremely expensive in comparison to the other methods.

10.48 Manholes

Manholes are sewer appurtenances which allow access to the sewer pipe underground. They are necessary so that proper preventive and emergency maintenance can be provided. Manhole rehabilitation is required to repair structural defects, eliminate I/I and correct corrosion deterioration of the manhole walls and steps.

There are numerous methods available for manhole rehabilitation. The methods should be evaluated based on the type of problem encountered and the physical characteristics of the manhole. In most cases a precast-concrete manhole requires different methods of rehabilitation than a brick manhole. Similarly, the rehabilitation of walls deterio-

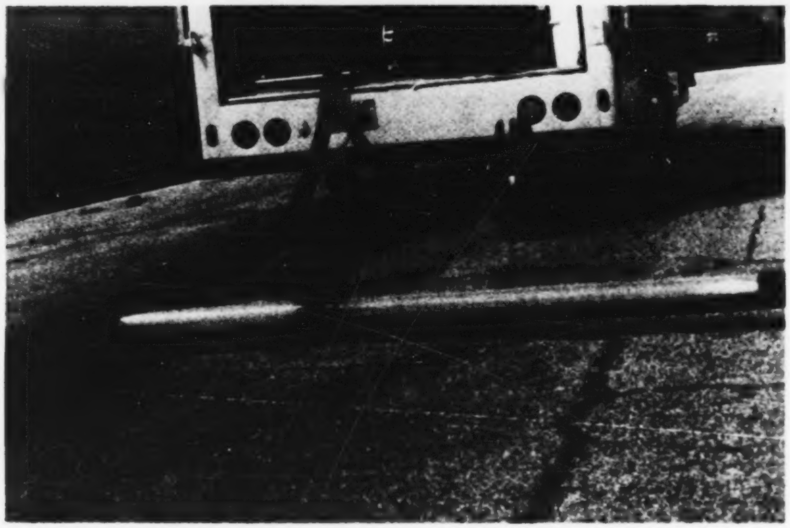

Fig. 10.41 Sewer service sealing unit

rated from hydrogen sulfide corrosion would be different than manhole wall rehabilitation to eliminate surface water inflow.

Most manholes allow inflow because of holes in the covers. These holes can be plugged in some manner or a manhole lid insert can be installed. The insert catches any water and does not allow the water to go into the sewer system. Newer, water-tight frames and covers have bolt-down covers which rest on a gasket set in the frame (Figure 10.42) and effectively seal out surface water.

Damage to the seal of the frame and grade adjustment area is a major source of inflow. This type of damage usually occurs whenever road work is initiated or during initial construction of the roads. Because the frame area lies under the paving close to the interface with the subgrade, a large volume of rainfall runoff is available and seeks the easy entry into the manhole. Several methods of in-place repair have been developed to handle this problem (Figure 10.43). Rubber seals which are held in place by tension bands can eliminate this excessive inflow. Also, chemical grouting with additional sealing of the open area has been very successful in elimination of inflow at this point.

Leaks in the sidewalls and base of manholes can be repaired by a combination of chemical grouting and coatings. The areas around a manhole are grouted by drilling holes through the manhole wall and pumping grout into the soil outside the manhole (Figure 10.44). This grout sets up in a way similar to pipe grouting and keeps water from entering the manhole in the joint or other damaged areas.

When walls have suffered deterioration due to hydrogen sulfide attack, they can be repaired with coating processes. The surface preparation is extremely important to insure the coating system will result in future protection (Figure 10.45). Thoroughly clean the walls to remove grease, sludge, mineral deposits and loose concrete or mortar. Patch all rough areas to provide a smooth surface which will receive the coating to be applied. The choice of coating material depends on the chemistry of the particular situation encountered. Various epoxys and plastics are available which can provide protection from hydrogen sulfide and are dependable coating processes (Figure 10.46).

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 293.

10.4U What type of coating can be used for corrosion protection?

10.4V What are segmented, fiberglass-reinforced cement liners and plastic liners used for in sewer rehabilitation?

10.4W List three methods of controlling I/I by chemical grouting of house service connections.

10.4X How should the walls of manholes be prepared before a protective coating is applied to the walls?

10.5 ADDITIONAL READING

SEWER REHABILITATION INSPECTOR HANDBOOK. Available from NASSCO, 101 Wymore Road, Suite 501, Altamote, Florida 32714. Price $42.50.

Fig. 10.42 Corbel/grade ring repair

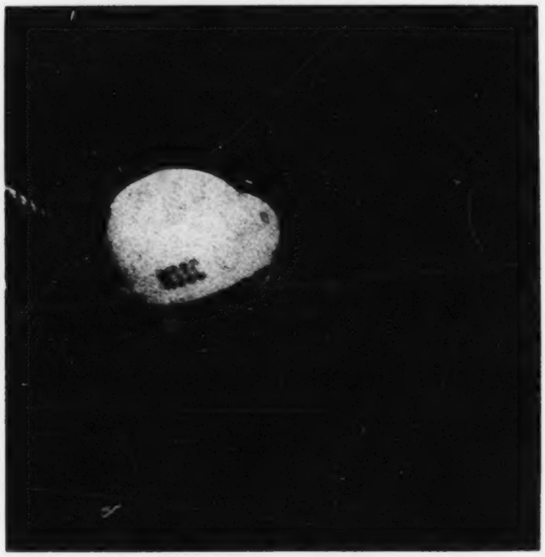

Fig. 10.43 Tucking saturated sewer jute under frame-corbel area to eliminate inflow

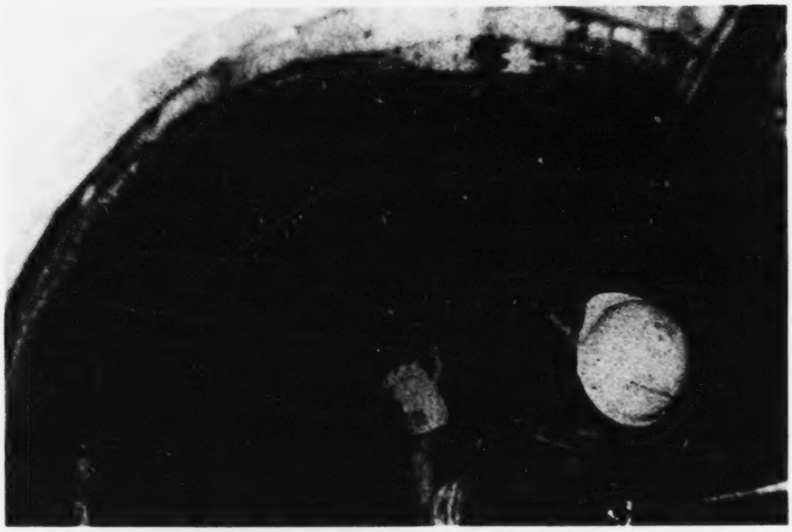

Fig. 10.44 Chemical grouting

Fig. 10.45 Surface preparation

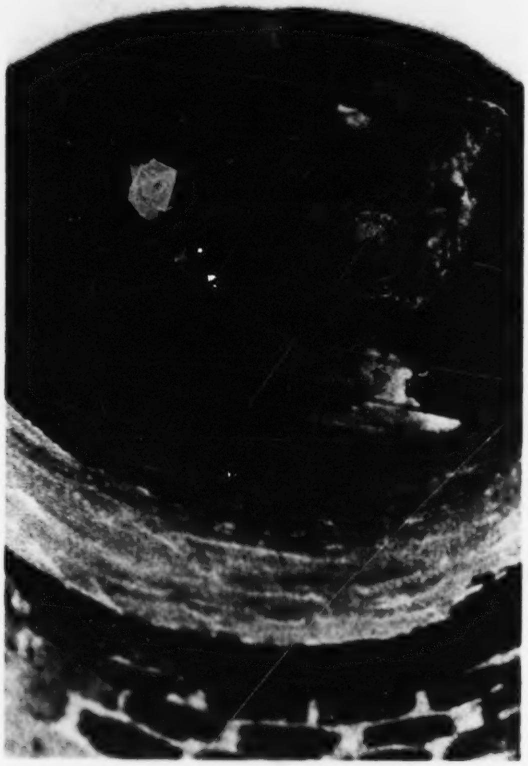

Fig. 10.46 Application of coating

DISCUSSION AND REVIEW QUESTIONS

Chapter 10. SEWER REHABILITATION

Please write your answers in your notebook before working the Objective Test on page 293. The purpose of these questions is to indicate to you how well you understand the material in this chapter.

1. What would cause sewers to lose their structural strength?
2. What techniques are available to determine the condition of a sewer system?
3. How can infiltration and inflow be measured?
4. What are the best open-channel, flow-metering manhole locations?
5. Smoke testing is an effective means of detecting inflow from what types of sources?
6. What operational problems can be directly attributed to defective collection systems?
7. How can a utility establish rehabilitation priorities?
8. Under what conditions should sewer rehabilitation by pipeline replacement not be considered?
9. What problems are common to all types of sewer construction?
10. What conditions must be suitable for chemical grouting to be successful?
11. What are the advantages and limitations of using shotcrete for sewer rehabilitation?
12. What type of precautions must be taken when erecting an Insituform insertion platform?
13. Why should the Insituform resin material be kept away from direct exposure to light?
14. How is a seal produced between the sewer and an Insituform liner in a manhole?
15. How are house service connections located in a sewer newly lined by the Insituform process?
16. What are the advantages and disadvantage of the Insituform method for rehabilitating sewers?
17. What are the reasons for lining a sewer?
18. Why should the public be notified and what should the public be told before a sewer lining project is started?
19. How would you insert a liner in a main line?
20. How are sections of liner pipe joined together?
21. Why should a lateral be lined?
22. How is the space between the manhole and the liner sealed?
23. Why is manhole rehabilitation required?
24. How can the walls of manholes that have deteriorated due to hydrogen sulfide attack be repaired?

SUGGESTED ANSWERS

Chapter 10. SEWER REHABILITATION

Answers to questions on page 245.

10.1A Sewers need rehabilitation to restore structural integrity and to control excessive additional inflow and infiltration flows during periods of rainfall or high groundwater conditions.

10.1B A physical survey of a collection system must be conducted to determine the condition of the system.

10.1C The present sewer maintenance program must be revised before the start of a sewer rehabilitation program to insure a coordinated effort of maintenance and rehabilitation.

Answers to questions on page 255.

10.2A The main reasons for the emphasis on reducing hydraulic inflow/infiltration loads on sewer systems and treatment facilities is that these loads increase treatment costs, result in the bypassing of untreated wastewater to the environment and can result in structural failure of weakened collection systems.

10.2B The flow components in a sanitary sewer are:

1. Base flow,
2. Infiltration, and
3. Inflow.

10.2C The possible surcharge potential for a metering location must be determined because surcharging results in non-uniform flow or backflow conditions which will result in faulty flow meter readings and possible damage to flow metering and recording equipment.

10.2D Smoke testing is not effective during high groundwater conditions or in sewers where sags or water traps are suspected or where sewers flow full. Smoke testing is also ineffective when the ground is saturated, frozen or covered with snow, and under windy conditions.

10.2E Dye-water flooding is applicable for:

1. Storm drains;
2. Drainage ditches, streams and water ponding areas;
3. Yard drains, areaway drains, foundation drains, roof drains and abandoned building sewers; and
4. Problem areas identified in other tests for which additional data are needed.

10.2F Closed-circuit television is the most effective method for identification and quantification of defects in sewer pipes. Other methods include visual inspection, lamping, smoke testing and flow measurements.

Answers to questions on page 257.

10.3A The four distinct courses of action that a utility may take with regard to a sewer system are (1) maintain, (2) replace, (3) relief, and (4) rehabilitation.

10.3B When determining the appropriate course of action, a utility should perform a quantitative evaluation of (1) sewer condition, (2) consequence of failure, (3) sewer capacity, (4) performance of sewers, and (5) costs.

10.3C Costs that should be considered when evaluating the cost effectiveness of an I/I rehabilitation program include:

1. Survey and rehabilitation costs,
2. Construction and capital costs, and
3. Operation and maintenance costs.

A comparison of the cost to transport and treat the rainfall- induced I/I with the cost to eliminate it will yield the most cost-effective solution.

Answers to questions on page 263.

10.4A The oldest and most common method of sewer rehabilitation is excavation and replacement.

10.4B The disadvantages of sewer rehabilitation by excavation and replacement are costs, traffic disruption, impact on other utilities, and disruption of lifestyle of people living and working in the area.

10.4C The most common method of sealing leaking pipe joints and circumferential cracks is the use of chemical grouting.

10.4D The success of chemical grouting can be tested by a low pressure-air test.

10.4E Shotcrete is sometimes referred to as gunite and is a mixture of sand, cement and water applied by air pressure.

Answers to questions on page 269.

10.4F Insituform is a method of pipe liner rehabilitation consisting of the installation of a new pipe within the old pipe without excavation. The process involves the use of a polyester-fiber felt tube, lined on one side with polyurethane and fully impregnated with a liquid thermal setting resin.

10.4G Materials and major pieces of equipment required for a typical Insituform installation include an insertion platform tube and elbow, portable mixer, transfer pump, vacuum pump, wet down conveyor system, lay-flat hose, hold back rope, water supply line, water control valve, circulating pump, boiler and heat exchanger, insitucutter, thermocouples, and polyurethane-coated, polyester-fiber felt liner, polyester resin, and catalyst.

10.4H The purpose of the Insitucutter is to cut out lining material in the areas in a sewer defined as service taps.

Answers to questions on page 278.

10.4I After the preparatory cleaning is completed on an Insituform sewer rehabilitation job, the internal inspection and evaluation team makes an inspection of the line to ascertain that the cleaning is complete and also to record on a TV log the location of all line deficiencies and service connections. In addition to the TV log, the line is video taped.

10.4J In the Insituform lining technique, the inversion platform is erected over the point of insertion of the line into the sewer being lined, usually over a manhole.

10.4K A liner can be tested for damages after it has been unpacked from its shipping container by attaching a vacuum pump to the bag and evacuating the entrapped air from the felt liner. It would be impossible to draw and maintain a vacuum with the system if the liner were damaged.

10.4L Safety precautions that should be taken during the installation and curing of an Insituform job include protection of workers, spectators, and equipment from hot water. Any time workers enter manholes, self-contained breathing apparatus, helmets, and harnesses must be worn. The strong volatile odors created during this process must be avoided.

Answers to questions on page 281.

10.4M Liners can be an effective method of repairing or reconditioning a sewer system by providing a new, smooth pipe to convey the wastewater. This new pipe does not leak (no infiltration or exfiltration) and prevents root intrusion.

10.4N A letter to homeowners explaining a slip lining project should indicate

1. Why the project is necessary,
2. What is planned,
3. What is expected to be accomplished, and
4. Direct costs to the homeowner.

The letter should state that the homeowner may be temporarily inconvenienced during construction and also explain the benefits that will result from the completed project. Also include a legally prepared form for the homeowner to sign giving the utility permission to perform any necessary repair work that may have an impact on the owner's property.

10.4O A sewer should be filmed or video taped before slip lining to locate laterals, any misalignment and any other discrepancy which may need to be corrected before the actual lining takes place.

10.4P Equipment needed to weld polyethylene pipes together includes fusion joiner jigs; mobile carts; a butt fusion tool or squaring tool; heating faces for heating saddles; tapping or coring tools and accessories for the adapting to the various sizes of pipe that will be used; and, the pulling heads.

10.4Q Three crews are recommended for a slip lining project:

1. One crew assembles the liner,
2. An excavating crew digs pull hole at pre-determined location, and
3. Another crew pulls liner into place.

10.4R The liner should be marked at 50-foot intervals so that if the pipe hangs up in the line, the pulling head location can easily be found and dug up.

Answers to questions on page 286.

10.4S When slip lining laterals, dig holes where the lateral connects to the main line and where the lateral enters the house.

10.4T The space between the liner and the manhole is sealed to prevent infiltration and/or exfiltration at the manhole.

Answers to questions on page 288.

10.4U Polyurethane resin coatings can be used for corrosion protection. 10.4V Segmented, fiberglass-reinforced cement liners and plastic liners are used for corrosion protection and to improve hydraulic capabilities.

10.4W Three methods of chemical grouting to control I/I in house service connections are to pump the service full of grout and use an auger to reopen the service, use the packer with tube known as a sewer sausage, and use a miniaturized camera-packer unit.

10.4X The walls of manholes should be thoroughly cleaned to remove grease, sludge, mineral deposits and loose concrete or mortar before a protective coating is applied. Also all rough areas should be patched to provide a smooth surface which will receive the coating to be applied.

OBJECTIVE TEST

Chapter 10. SEWER REHABILITATION

Please mark the correct answers on an answer sheet as directed at the end of Chapter 1. There may be more than one correct answer to the multiple choice questions.

1. Major sources of information for the proper development and completion of a sewer system inventory include
    1. As-built drawings.
    2. Contractor's personnel.
    3. Key maintenance personnel.
    4. Maintenance repair and inspection reports.
    5. Sidewalk superintendents.
2. Problems created by higher flows in sewers include
    1. Backflooding into private property.
    2. Damage and accelerated wear of pumping equipment.
    3. Degradation of environment due to overflows.
    4. Reduction of voids around sewers.
    5. Treatment processes adversely impacted.
3. Limitations of using weirs to measure flows in sewers include
    1. Buildup of debris causing inaccurate readings.
    2. Inaccurate readings due to low flows.
    3. Inaccurate readings due to rags.
    4. Reduction of hydraulic capacity of sewer.
    5. Reduction of sludge accumulation.
4. The major sources where rainfall-induced I/I enter a sewer system are
    1. Flow meters.
    2. Lift stations.
    3. Manholes.
    4. Sewer house connections.
    5. Sewer mains.
5. Types of leaks in sewer mains which contribute to rain-induced I/I include
    1. Defective joints.
    2. Holes in cover.
    3. Service taps.
    4. Storm drain cross connections.
    5. Through brickwork under ring.
6. Types of leaks in manholes which contribute to rain-induced I/I include
    1. Around sewer pipes entering manhole.
    2. Defective cleanout leak.
    3. Holes in cover.
    4. Through base of manhole.
    5. Through manhole joints.

7. Types of leaks in sewer house connections which contribute to rain- induced I/I include
    1. Defective cleanout leaks.
    2. Foundation drain hookups.
    3. Joint leaks.
    4. Multiple damage leaks.
    5. Roof drain connections.

8. Techniques used to determine location of rainfall-induced leaks into collection systems include
    1. Bucketing.
    2. Dye-water flooding.
    3. Rodding.
    4. Leak quantification.
    5. Smoke testing.

9. When examining sewer pipe for structural defects, which of the following items should be recorded?
    1. Corrosion of pipe walls
    2. Cracked joints
    3. Frame and cover condition
    4. Root intrusion
    5. Step condition

10. When examining manholes for structural defects, which of the following items should be recorded?
    1. Channel condition
    2. Corrosion of walls
    3. Cracked joints
    4. Visible leakage
    5. Wall condition

11. Information that can be obtained from a closed-circuit television inspection includes
    1. Grease accumulation.
    2. Location and quantity rating of root intrusion.
    3. Missing pipe.
    4. Sewer sags.
    5. Step condition.

12. Sewer rehabilitation by pipeline replacement results in
    1. Additional incidental I/I sources.
    2. Correction of misalignment of pipe.
    3. Increase in hydraulic capacity of sewer.
    4. Reduction in surface flooding from storm waters.
    5. Repair of improper service connections.

13. Construction problems unique to sewer line excavation and replacement include
    1. Effect on other utilities.
    2. Maintaining flow.
    3. Noise.
    4. Removal and disposal of old pipe.
    5. Traffic disruption.

14. The basic groups of grouting chemicals include
    1. Foams.
    2. Gels.
    3. Plastics.
    4. Polymers.
    5. Shotcrete

15. Defects in an Insituform bag liner may be caused by
    1. Curing water.
    2. Handling on job site.
    3. Manufacturing.
    4. Shipping.
    5. Vacuum pressures.

16. What environmental factors can influence the actual increase in the temperature of the liner bag during an Insituform sewer rehabilitation job?
    1. Backfill
    2. Groundwater
    3. Microorganisms
    4. Traffic
    5. Vegetation

17. The problems associated with an Insituform liner bag that is too long include
    1. Additional manpower to remove uninverted cured portion of bag.
    2. Excess length will hinder flow through manhole.
    3. Extra costs.
    4. Prevention of the hot water in the lay-flat hose from discharge at the liner end of the bag.
    5. Wasted bag and resin.

18. The advantages of the Insituform method are
    1. Easy to observe the method.
    2. No excavation.
    3. No interruption of utility service.
    4. Reduced cost.
    5. Total elimination of I/I.

19. Before lining a sewer, which of the following tasks should be completed?
    1. Make the liner slippery
    2. Notify the public
    3. Plan the operation on a step-by-step basis
    4. Take photos of the yard around each house where landscape or grounds could be disturbed by the lining operation
    5. Televise the sewer

20. Sources of I/I entering a house service line include
    1. Joints in service line.
    2. Lift station.
    3. Manhole.
    4. Point of connection to main.
    5. Structural damage from construction.

End of Objective Test

CHAPTER 11

SAFETY/SURVIVAL PROGRAMS FOR COLLECTION SYSTEM OPERATORS

by

Glenn Davis

Revised by

Rick Arbour

TABLE OF CONTENTS

Chapter 11. Safety/Survival Programs for
Collection System Operators

Page

OBJECTIVES 297

11.0 Safety/Survival 298

11.1 Professionalism 299

11.2 The Numbers Game or How Dangerous is the Collection System? 299

1. Slips 299
2. Falling Objects 299
3. Infections and Infectious Diseases 299
4. Lacerations and Contusions (Tears and Bruises) 300
5. Falls 300
6. Explosions 300
7. Poisonous or Toxic Gases 301
8. Oxygen Deficient Atmospheres 301
9. Strains or Ruptures 302
10. Traffic Mishaps 302
11. Bites (Insects, Bugs, Rodents, Snakes) 302
12. Excavation and Trench Shoring 302
13. Drowning 302
14. Fire 302
15. Electrical Shock 302
16. Noise 302

11.3 Major Types of Accidents and Injuries 303

11.4 Safety/Survival Program Benefits 303

11.5 Establishing a Safety/Survival Program 306

11.6 Safety/Survival Program Responsibilities 306

11.61 Top Administration 306
11.62 Safety Department Staff 306
11.63 Manager, Supervisor, Field Personnel 306

11.7 Monthly Safety Meetings 308

11.8 Safety Committee 308

11.9 Safety/Survival Program Policies 308

11.10 Records 309

11.11 Additional Reading 309

11.12 Acknowledgment 311

SUGGESTED ANSWERS 312

OBJECTIVE TEST 313

OBJECTIVES

Chapter 11. SAFETY/SURVIVAL PROGRAMS FOR COLLECTION SYSTEM OPERATORS

After completion of Chapter 11, you should be able to do the following:

1. Demonstrate your *AWARENESS* of the hazards of working in the collection system environment by performing your assigned duties safely,
2. Identify potential and existing hazards,
3. Develop and establish a safety/survival program,
4. Outline the objectives and benefits of a safety/survival program,
5. List the responsibilities of the different staff levels in a collection system agency that are responsible for a safety/survival program,
6. Prepare and conduct tailgate safety sessions and monthly safety meetings,
7. Develop and implement appropriate safety/survival program policies, and
8. Accurately complete accident forms and properly maintain records.

CHAPTER 11. SAFETY/SURVIVAL PROGRAMS FOR COLLECTION SYSTEM OPERATORS

11.0 SAFETY/SURVIVAL

- SEWER FUMES KILL PAIR, STOP WOULD-BE RESCUERS
- JOB SURVEY REVEALS DISMAL PERFORMANCE BY WASTEWATER INDUSTRY
- SEWER WORKER KILLED
- DITCH COLLAPSE KILLS ONE
- POISONOUS GAS KILLS 7, INJURES 28
- SAFETY SURVEY REVEALS FATALITY INCREASES
- BACK INJURIES COST 10 BILLION DOLLARS IN WORKERS' COMPENSATION CLAIMS
- MAN BURIED ALIVE
- COLLECTION SYSTEMS LEAD RISE IN INJURY RATES
- WASTEWATER INDUSTRY RETAINS #1 STATUS AS THE LEAST SAFE INDUSTRY

FIGMENTS OF THE IMAGINATION? - NO! These are actual statements taken from a variety of recent sources which underscore why this chapter is titled "Safety/Survival Programs for Collection System Operators."

Throughout the world most living things devote considerable time and energy to survival. At every level of life whether it be human beings, animals, insects, fish, or fowl, survival occupies a great part of every living hour. Intelligent people not only try to protect themselves from injury or death, but they also strive to protect their fellow human beings and especially their immediate families and coworkers. An accident is a tragedy for your family and others who depend on and love you, as well as for yourself.

This chapter and Chapter 4, "Safe Procedures," are the two most important chapters in the entire course since they deal directly with your ability to survive by avoiding a fatality or disabling accident when working in the collection system environment.

No other skill more clearly demonstrates the professionalism of the collection system operator than his or her ability to carry out a work assignment safely. An amateur may perform all of the tasks of a collection system operator, but a truly professional operator will do a better job, will do it more quickly, and will always do it more safely.

Unfortunately, even the formal surveys conducted by the various organizations such as the WPCF and National Safety Council do not accurately reflect the seriousness of the problem. The 1985 WPCF Safety Survey, for example, reports only three fatalities in collection systems. There are, however, far more fatalities and injuries which occur throughout the nation in collection systems. Many agencies do not participate in these surveys, and the fatalities and injuries that do occur are often not reported and, therefore, are not incorporated into the statistics. As grim as the numbers game seems, it is actually far worse than portrayed by the formal surveys. A more accurate estimate of fatalities in collection system operations nationwide is between 2500 and 3000 per year. It is tragic that, in many agencies, collection system operators are not even remotely aware of the hazards that they face in the everyday performance of their tasks. The key to the safety/survival is *YOU.*

In recent years a considerable amount of information has been compiled regarding fatalities and injuries in the collection system field. The findings only confirm what many have known for some time:

- Mayors, city council members, city administrators, department heads, safety department personnel or consulting engineers are not usually the victims of accidents and fatalities.
- Collection system operators, line supervisors or others who are directly involved and exposed to hazards while doing everyday routine tasks are the ones who experience the injuries and fatalities.
- Formal procedures and/or safety equipment generally are not being used when accidents occur, although they are frequently available for the injured operators.
- Time and resources for investigations, analysis and implementation of safety programs were always available after the incident, i.e., money, equipment, and training.
- One or more of three common factors are usually missing when an accidents occurs.

  - Awareness
  - Responsibility
  - Commitment

All of the incidents listed at the beginning of this chapter could probably have been prevented if the operators involved had been aware of the hazards, had assumed some responsibility for their own safety/survival, and had made a commitment to that responsibility.

In no other industry in the United States today is a safety/survival program more critical than in collection system agencies, as our injury records so clearly demonstrate. The cost of human suffering is incalculable. Consider the effect, for example, on you and your family if you had to spend the rest of your life with only one eye, because you failed to wear safety glasses while working around a pump and the coupling happened to disintegrate while you were inspecting it. Or what if a wrench drops out of your co-worker's pocket while he is leaning over the entrance tube to the lift station? It strikes you in the head at the bottom of the entrance tube, traveling at about 75 miles per hour. How much pain and anguish could you have spared yourself and your family by taking the time to put on a hard hat?

Obviously, accidents have a significant economic impact as well as the human suffering toll. For example, workers compensation rates, liability insurance, disability insurance, and other similar costs are directly related to our performance in an agency or company. In recent years, all of these costs have skyrocketed, imposing an economic hardship on many agencies and communities. These are budgetary resources which are no longer available for use in other areas such as collection system operation, maintenance, training, equipment, and salaries.

11.1 PROFESSIONALISM

This is substantiated by the figures reported in the 20th Annual Water Pollution Control Federation (WPCF) Safety Survey Report, which reviews data on injuries and fatalities based on information submitted by 1,334 agencies in the United States and Canada in 1985. This analysis reports:

- 50% of all injuries occurred to employees with 0-5 years of wastewater experience.
- 74% of the injured had 0-10 years' experience.
- 72% of all injuries were attributed to non-certified employees.

Safety/survival is directly related to your level of professionalism which in turn in directly related to knowledge and ultimately certification.

As your collection system continues to expand, it is imperative that your level of professionalism increase as well through increased knowledge. Nowhere is this more obvious than in your Collection System Safety/Survival Program.

The overall objective of this chapter is to make you *AWARE* of the hazards of working in the collection system environment. The other two factors, *RESPONSIBILITY* and *COMMITMENT*, will be up to you. The rest of this chapter provides additional information regarding details of collection system accidents, and a significant portion of the chapter will be devoted to establishing a comprehensive safety/survival program in your collection system.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 312.

11.0A One or more of what three common factors are generally missing when an accident occurs?

11.1A What skill most marks the professionalism of the collection system operator?

11.1B What is the overall objective of this chapter?

11.2 THE NUMBERS GAME OR HOW DANGEROUS IS THE COLLECTION SYSTEM?

Multiple hazards exist in the performance of the collection system operator's routine daily tasks and work assignments. Most of these hazards and appropriate precautions are described fully in Chapter 4, SAFE PROCEDURES. Awareness of these hazards will enable you to take responsibility for your own safety. The following brief review is intended to refresh your memory about the material in Chapter 4.

1. **SLIPS** - Wet wells, metering flumes or other structures with live flows can be and usually are extremely slippery because of the accumulation of slime and/or the very humid atmosphere. Emergencies, pumps station failures, or other difficult situations which are often caused by bad weather require extra caution. For those who work in the northern climates, snow, ice, frost and below-freezing temperatures demand extra caution in the winter time.

2. **FALLING OBJECTS** - In lift stations and manholes, take precautions against falling objects. When working in a pre- fabricated type of lift station, never stand directly under the entrance tube, particularly when raising or lowering materials/supplies/tools. Even if such objects are placed in a container of some type, they could tip out and fall or the container could bump the sidewalls and dislodge dirt or debris. Similarly, when operators are working in manholes, take care not to place tools and materials close to the manhole rim where they can be accidentally kicked into the manhole.

3. **INFECTIONS AND INFECTIOUS DISEASES** - We know that collection systems are not the cleanest places to work. Every collection system operator must realize that wastewater is contaminated with possibly every kind of infectious microorganism that can be carried in wastewater. Like the medical doctor, the collection system operator may be exposed to many of the *PATHOGENIC ORGANISMS*[1] from the entire community in which you work. Also like the doctor, personal health depends to a great extent upon your personal cleanliness. Both you and the doctor must wash your hands before smoking or eating. Fortunately, neither profession suffers an unusually high incidence of infection. This may be because both recognize the importance of personal cleanliness. It is also possible that

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[1] *Pathogenic Organisms (path-o-JEN-nick). Bacteria, viruses or cysts which can cause disease (typhoid, cholera, dysentery). There are many types of bacteria which do* NOT *cause diseases and which are* NOT *called pathogenic. Many beneficial bacteria are found in wastewater treatment processes actively cleaning up organic wastes.*

collection system operators develop immunities to infectious diseases and that the records reporting diseases are inadequate.

Diseases or infections that collection system operators could come in contact with on the job include:

Typhoid and paratyphoid fever
Cholera
Bacillary dysentery
Amoebic dysentery
Roundworm and other worm infections
Tuberculosis
Poliomyelitis
Infectious hepatitis
Leptospirosis (Weil's disease)
Tetanus

How can you determine if you have contracted one of these diseases? The best indication is that you don't feel well. If you have headaches, feel sick to your stomach, have diarrhea, feel feverish or sleepy, you should see your physician. Prompt action by your physician can save you a lot of pain and trouble in the future and also help protect your family, friends and your fellow operators. See Chapter 4, Section 4.3, "Classification and Description of Manhole Hazards," and Section 4.5, "Precautions for Manhole Entry," for more information.

Public Health officials generally agree that tetanus, polio and typhoid infections are especially hazardous for anyone coming in contact with wastewater. Typhoid, once was considered the most dangerous water-borne infection, is now more easily cured by recent medical discoveries. Immunization against typhoid is only about 60 percent effective. Polio immunization (especially Salk vaccine) is effective and simple to administer, but this is still a very dangerous disease, especially to younger operators. Tetanus is easy to prevent but difficult to treat and is considered the most dangerous of the three diseases. *ALL THREE DISEASES SHOULD BE INCLUDED IN THE COLLECTION SYSTEM OPERATOR'S IMMUNIZATION SCHEDULE WITH BOOSTER SHOTS AT RECOMMENDED INTERVALS.*

Tetanus immunization recommendations have changed in recent years. In the past, it was recommended that a booster shot be given as frequently as once year. However, recent research indicates that if this schedule is maintained, sensitization can occur in three to five years resulting in loss of protection. Prior to receiving a tetanus booster, you should check with either local or state health departments to determine the recommended frequency of the booster shots. In some cases this recommendation is now every ten years unless a specific incident occurs.

The AIDS virus is a new concern for collection system operators. As of January, 1986, the Centers for Disease Control in Atlanta, Georgia, provided the following information:

> Over 95% of all AIDS cases have been related in some way to intimate sexual contact, drug abuse, or blood transfusions. There is no evidence at this time to indicate that the AIDS virus is transmitted through contact with raw sewage (urine and feces).
>
> There has never been a recorded case of AIDS that can be attributed to working in the wastewater collection and treatment industry. This has been true to even the large gay population areas.

Although it cannot be definitely said that AIDS is not contracted through contact with raw wastewater, all evidence points in this direction. Hopefully future research will be able to define exactly how the AIDS virus can be transmitted.

For further information, the Centers for Disease Control can be reached by calling their hotline at 1-800-342-AIDS. Local health departments are also useful sources of up-to-date information about AIDS. For additional information, see *OPERATIONS FORUM*, June 1987, page 3, "Answers About AIDS."

Common sense along with protective clothing and personal cleanliness will go a long way to protect you from infections.

4. **LACERATIONS AND CONTUSIONS (Tears and Bruises)** - Much of our daily work involves working with hand tools, heavy equipment, and machines that are rusted, corroded, or nearly inaccessible. Planning each job and using the right tools in good operating condition will minimize smashed knuckles and thumbs.

5. **FALLS** - Manhole steps are notorious for giving way after a period of exposure to the frequently corrosive atmosphere where they are installed. Pump station dry and wet well access is usually by ladder rather than stairs. Atmospheric conditions, rain, and snow will all make ladder rungs slippery. Under no circumstances should you try climbing or descending ladders or manhole steps one-handed while carrying tools/equipment in the other hand.

6. **EXPLOSIONS** - Each year throughout the country there are numerous explosions in collection systems caused by a buildup of explosive gases in the sewer line or underground structure. Such buildups are very unpre-

dictable and can come from any number of sources such as natural gas leaks, vehicle tank truck accidents that release flammable material into storm and/or sanitary sewer, or flammable material discharges from industries.

Anyone who has seen the results of an explosion either in a sewer, a digester, or other type of enclosure, is well aware of the havoc that can be caused by just the right explosive mixture of air and an explosive gas. Too rich a mixture or too lean a mixture of a combustible gas will not explode. But when the mixture of air and gas is within the level of explosive limits, a spark from an automobile, an improper tool, or even a shoe nail, as well as the more obvious open flame or cigarette may set off the explosion. Only extremely well trained and knowledgeable persons (such as gas company experts) should consider working around such dangerous atmospheres and then only when proper ventilation and hazard removal or elimination has been verified as impossible (carbon dioxide fire extinguishers have been used by experts to dilute explosive mixtures when necessary).

Experts from the gas company may be called upon in an emergency to work in or near explosive mixtures. *THESE SPECIALLY TRAINED OPERATORS* with years of experience can be trusted to perform such dangerous work if no other feasible alternatives exist. A true expert is a person who always knows and works within their own limits with plans for backup or alternative action if suddenly confronted with a new emergency.

Special insight can be gained by discussing explosive hazards with your local fire department personnel. If your agency has pretreatment facility inspectors or industrial waste inspectors , they should have a knowledge of the areas that are most likely to discharge hazardous combustible materials to the wastewater system but if they don't, it is your responsibility to locate these potentially hazardous sources. Another good way to gain assistance when searching for sources of hazardous gases is to contact your local gas company. Many times explosive conditions are caused by leaking gas mains, service lines or underground fuel storage tanks. In combined wastewater collection systems where any spill of gasoline on a public street may find its way into the collection system, particularly hazardous conditions can develop as far as explosive mixtures are concerned.

7. **POISONOUS OR TOXIC GASES** - This situation might arise anytime, anywhere, from a variety of sources ranging from natural decomposition of the organic solids in wastewater to toxic chemical dumping, or reactions from two or more chemicals.

A number of toxic gases are found in the wastewater collection system. Hydrogen sulfide is the most dangerous and most likely to be encountered because it is generated during the *ANAEROBIC DECOMPOSITION*[2] of organic matter and it is heavier than air and tends to concentrate near the bottom of enclosed spaces. Hydrogen sulfide smells like rotten eggs but unfortunately, our noses tend to lose their sensitivity to hydrogen sulfide and become unreliable detectors. Many operators as well as their would-be rescuers have been killed by this gas. Other toxic or poisonous gases found in collection systems include carbon monoxide, ammonia and chlorine. Industrial chemical discharges can release dangerous gases through accidents, leaks or illegal discharges. Toxic spills from highway and railway accidents also reach the sewers.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 312.

11.2A List the hazards discussed in this section that might be encountered by collection system operators in the performance of routine daily tasks and work assignments.

11.2B Where and under what conditions are operators most likely to slip and fall?

11.2C Can *AIDS* be contracted from working in the wastewater industry?

11.2D How can an explosion in a sewer be set off when the mixture of air and gas is within the level of the explosive limits?

11.2E What gas is the most dangerous and most likely to be encountered in collection systems?

8. **OXYGEN DEFICIENT ATMOSPHERES** - A safe supply of oxygen is essential to you in the environment in which you must work. ANY concentration of OTHER GASES can reduce the amount of oxygen available for life support. A shortage of oxygen to the operator produces a shortage of oxygen to the brain, which in turn makes the operator less alert. If you are less alert, you may not recognize the danger until you are too weak to get out. Each year many operators die from toxic hydrogen sulfide, a shortage of oxygen, or from falls or unsafe acts in attempts to escape without help when the operator is mentally disabled, at least in part, by a toxic gas or insufficient oxygen.

---

[2] *Anaerobic Decomposition (AN-air-O-bick). The decay or breaking down of organic material in an environment containing no "free" or dissolved oxygen.*

The views of experts and legal regulations vary regarding safe levels of oxygen, as do individual needs concerning the amount of oxygen required to support life. Your health and the amount of energy expended are considerations in determining the amount of oxygen that you need. It is generally agreed that anything less than 19.5 percent of oxygen in the breathing atmosphere is a signal to the trained collection system operator to be especially careful and request more ventilation. Measure the percent of oxygen in the air at the work site. You must realize that through normal draft ventilation the gases exiting the collection system through an open working manhole could be just as toxic as the atmosphere in the collection system. Any time the percent of oxygen in a manhole starts dropping below the percent topside, increase the ventilation. Carry properly calibrated oxygen level measuring devices which sound an alarm when a dangerous condition exists rather than a device where you must read a meter and then decide if the oxygen level is deficient.

Ironically, one of the most dangerous situations occurs during the new construction inspection period. You may be required to visually inspect the inside of a newly constructed pipeline, but such a pipeline ordinarily has no provision for introducing ventilating air to maintain a safe environment. This is frequently the site of operator suffocation in the collection system. Other collection system structures where an oxygen deficient atmosphere may be encountered include confined spaces such as manholes, sewer lines and wet wells.

Beware of the possibility of excessively high levels of oxygen, too. High oxygen levels won't harm you, but they increase the hazards of explosion and fires. Hazardous levels of oxygen can result from the use of pure oxygen for hydrogen sulfide (H2S) control (Chapter 6, Section 6.6, "Hydrogen Sulfide Control," especially Section 6.653, "Pure Oxygen") in collection systems and in the activated sludge process of wastewater treatment plants. An upper limit of 21.9 percent in working atmospheres is suggested.

9. **STRAINS OR RUPTURES** - By virtue of our work, pulling manhole covers, maneuvering equipment in tight places such as pumps and motors, we open ourselves up to strains and ruptures of all types. Back injuries are probably the most serious since, in most cases, the parts that make up your backbone are not able to repair themselves and damage is often cumulative. It is extremely important to understand and use proper techniques when working in the collection system environment, since an injury could have a drastic impact on your ability to earn a living or enjoy life as you get older.

10. **TRAFFIC MISHAPS** - This is an especially high risk area in that we must frequently access a collection system from streets and roadways. Given the number of careless and inattentive drivers we see every day, it certainly makes sense to take all the precautions necessary for maximum protection when working in streets and roadways.

11. **BITES (INSECTS, BUGS, RODENTS, SNAKES)** - Bites can range from inconvenient to very serious. In some parts of the country black widow spiders, poisonous snakes, and scorpions find collection system facilities and structures such as manholes, metering enclosures and electrical control enclosures ideal places to live. Use gloves and protective clothing and stay alert.

12. **EXCAVATIONS AND TRENCH SHORING** - Cave-ins rank among the top causes of fatalities in the collection system. You should not, under any circumstances, enter a trench unless you fully understand and insist on adequate safety precautions.

    As a collection system operator, you may be asked to inspect or advise about collection system construction or repair excavations made by your agency or by contractors working for your agency. Along with the engineer, you may be the most informed professional to re-examine, inspect, and help enforce OSHA safety laws. Watch out for your own safety and that of your fellow operators.

    Deep excavations (5 feet or deeper) without shoring or with improper shoring have allowed cave-ins that have killed many operators. There is a great temptation to "short-cut" the possible expense and time-consuming labor of shoring and a contractor principally interested in making a profit may be tempted to save on shoring or other safety measures. As a trained collection system operator, you should take seriously your responsibility to be on the lookout for such hazardous operations.

13. **DROWNING** - Drowning is probably an unpleasant way to die, but drowning in raw wastewater has to be worse. Use extreme care when working in high velocity sewers such as metering flumes and observe all of the confined space precautions to avoid losing consciousness and falling into the wastewater.

    Confined space precautions include use of safety harness, life lines, and two people topside to watch, assist and help remove the in-line worker by winch or their own physical strength if the worker gets into trouble.

14. **FIRE** - Fire hazards, primarily in lift stations, develop from a number of sources. Of particular interest is the risk that fire could easily block the limited access into pump stations or other structures where we normally work, thus trapping an operator.

15. **ELECTRICAL SHOCK** - This hazard exists in virtually all of our facilities and is made even more threatening by the damp atmosphere and adverse working conditions in which we must work. There is a misconception that only high voltage kills. That is not the case, however, since relatively low voltage, even 120 volts, will kill you as quickly and effectively as 480 volts. Under no circumstances should you do electrical work that you are not qualified to perform or not authorized to perform.

SKREEEE
POW
EEEE

16. **NOISE** - Engine-driven pumps, standby power generators, large ventilation blowers, air compressors, jack hammers, concrete cut-off saws and high velocity cleaners are examples of equipment noise we are exposed to which can result in permanent hearing loss over a period of time unless adequate hearing protection is worn.

Curiously enough, workers for other industries, such as construction and mining, are exposed to these same hazards as well as many others. Yet, in comparison to those industries, we have retained the number one position as the *LEAST* safe industry. This ranking is substantiated by nationwide industry surveys through the Water Pollution Control Federation (WPCF) and the National Safety Council. Figure 11.1 illustrates the injury frequency rate (number of injuries per million manhours worked) for collection system operators over the last ten years. Although the rates in 1985 decreased slightly, from 78.2 injuries per million manhours to 73.37 injuries per million manhours, the rate remains disturbingly high. In a similar survey,[3] the National Safety Council survey reports an injury frequency rate for collection system operators of 4-1/2 times the 1984 average for all industrial workers. This same survey also reports that the severity rate for operator injuries is almost five times the average rate for other industrial workers. These figures may seem academic and irrelevant. They are not. They relate directly to your chances for a long, healthy life. What they say is that *YOU* are at serious risk of suffering a very severe work-related injury every time you go to work. The good news is, you can change the odds. Your participation in this course is an excellent beginning. We now know that 72 percent of operator injuries are attributable to non-certified operators and that 72 percent of those who are injured are non-certified operators.[4] So, while certification is no guarantee of good health, the statistics clearly suggest that certification in some way improves your chances.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 312.

11.2F When might an operator encounter oxygen deficient atmospheres?

11.2G Why are traffic mishaps a high risk area for collection system operators?

11.2H Where will collection system operators most likely find black widow spiders and scorpions?

11.2I List two sources of equipment noise which can result in permanent hearing loss.

11.2J Injury frequency rates and severity rates for collection system operators were how many times greater than the average rate for industrial workers in 1984?

11.3 MAJOR TYPES OF ACCIDENTS AND INJURIES

Three major types and causes of accidents accounted for 81 percent of all the injuries reported to the Water Pollution Control Federation (Figure 11.2).

- 43.4% **sprains and strains** resulting either from lifting, pulling or pushing objects, awkward position or sudden twist, or slips are the leading causes of accidents reported.
- 23.8% **struck by objects** either stationary, moving, sharp, falling, or flying.
- 14.2% falling either to different levels from platforms, ladders, or stairs or on the same level to the working surface.

The parts of the collection system operator's body that are frequently injured are the back, hands and legs (Figure 11.3).

- 27.0% of the accidents are back injuries which lead the category of most common parts of the body injured.
- 13.2% are hand injuries, and
- 12.9% are leg injuries, which is consistent with national trends by industrial workers.

In spite of the poor safety record of the collection system industry, 63.3 percent of the agencies reporting had a formal safety program. However, based on the numbers above, the safety programs obviously are not always effective. If you are currently working in the wastewater industry, you can expect at least a one-in-ten chance of experiencing a disabling injury.

In summary, it should be readily apparent at this time just how important safety/survival is to every collection system operator. It should be obvious to you that the operator is the person who is most frequently exposed through everyday work assignments and has the greatest to lose in terms of injury or death. Therefore, operators should share a larger portion of the responsibility for developing effective safety/survival practices when performing these work assignments. A comprehensive Safety/Survival Program greatly increases operator involvement and minimizes risks to the operators in the field. The remainder of this chapter will address the operator's role in a safety/survival program, and will provide an overview of how an effective safety program operates. This information should provide you with the tools to initiate a program or to strengthen an existing program, since it forms the basis for the first of the three factors required for safety, awareness through knowledge.

11.4 SAFETY/SURVIVAL PROGRAM BENEFITS

Industry and government experiences repeatedly show strong evidence that the human and economic benefits of accident prevention far outweigh the investment in training and protective devices necessary for a sound safety/survival program. Personal injuries and economic factors such as work interruptions and output delays are two of the primary considerations.

- Humanitarian. First and foremost, the greatest return in a safety/survival program is the prevention of human suf-

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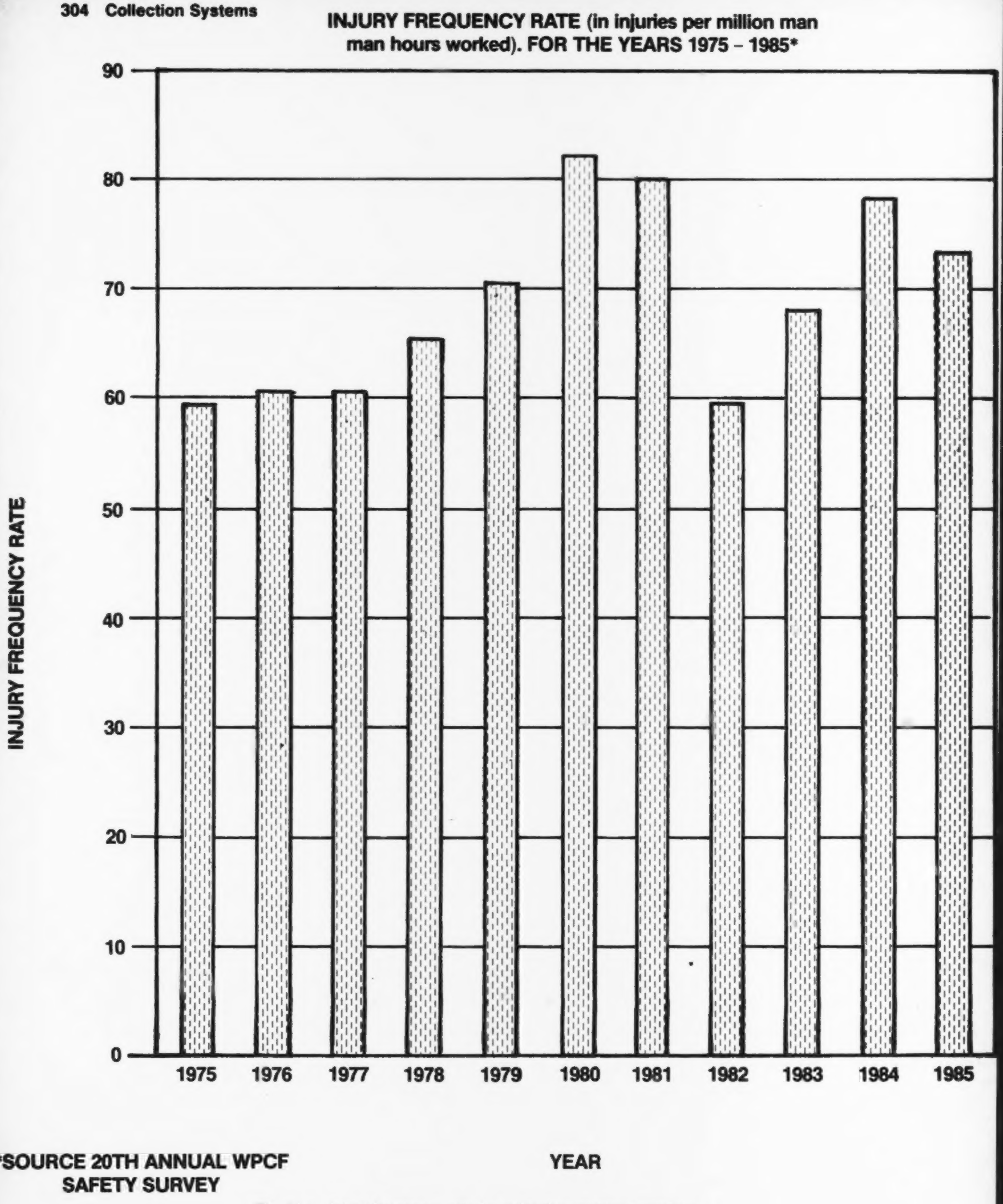
[3] *ACCIDENT FACTS, 1985 edition, National Safety Council.*

[4] *Twentieth Annual Water Pollution Control Federation Safety Survey.*



*SOURCE 20TH ANNUAL WPCF
SAFETY SURVEY

Fig. 11.1 Injury frequency rate for collection system operators

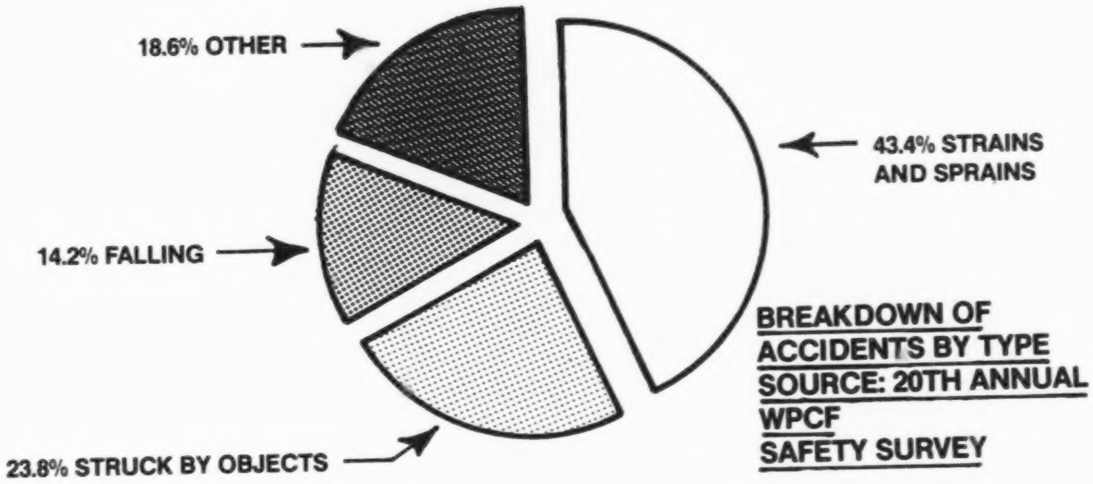


Fig. 11.2 Breakdown of accidents by type

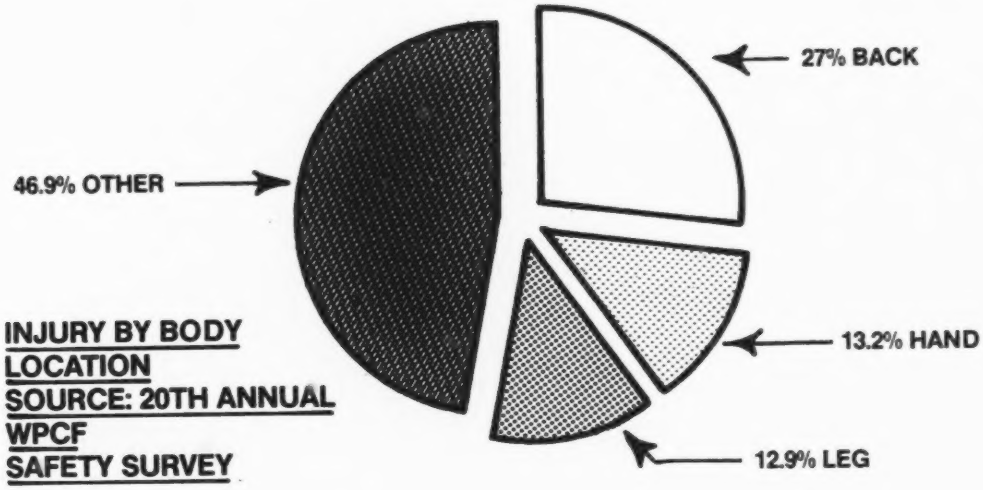


Fig. 11.3 Injury by body location

fering, either in the form of permanent disability or even death.

- Economic. Although it may not be readily apparent, the economic savings resulting from an effective safety/survival program are enormous. An accident is evidence of inefficiency that affects both the quality and quantity of productive effort. Costs associated with lost work output, damaged equipment and material, higher insurance premiums, employee morale, the loss of experienced operators, and the training of new operators are all related economic factors. The direct economic loss to you and/or your family in the case of permanent disability or death is even more significant. It is apparent, too, that your responsibility to taxpayers is an economic factor since a higher cost for the services you perform will have to be passed on to them.

Your safety and that of your colleagues should be the first consideration in the performance of your duties and assigned tasks in the collection system. The basis for your program should be:

SAFE OPERATIONS SHALL TAKE PRECEDENCE OVER EXPEDIENCY OR SHORT CUTS.

11.5 ESTABLISHING A SAFETY/SURVIVAL PROGRAM

Typically, the structure within an agency for a safety program consists of the following levels:

1. Administration Department which states, "We will have a safety program";
2. Safety Department which says, "We will help with the resources"; and
3. Safety Committee which is "where the corrective action is."

SAFETY ASSIGNMENT: DO AS I SAY... NOT AS I DO!!

Depending on the size of your operation, there may be some additional levels of safety/survival activity in between these levels, but this basically describes a typical structure. Perhaps a little more difficult, however, is the definition of the responsibilities in each of these areas.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 312.

11.3A Why do the formal accident surveys not accurately portray the severity of the safety problem in the collection system industry?

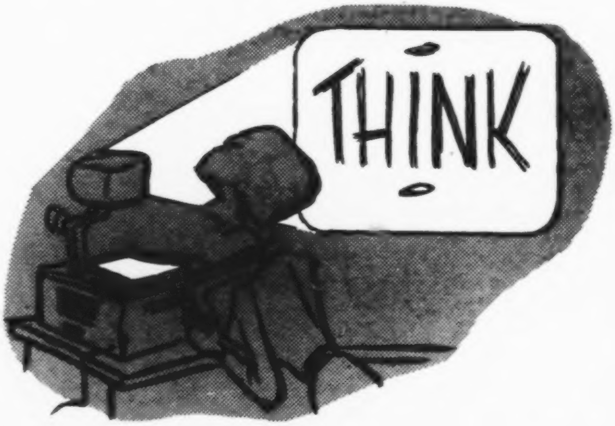
11.4A What should be the basis for a safety/survival program?

11.5A List the three levels of structure within an agency for a safety program.

11.6 SAFETY/SURVIVAL PROGRAM RESPONSIBILITIES

11.61 Top Administration (Top administration could be the mayor, city council members, agency directors, or other top management personnel involved with the policy making aspect of your agency.)

- They bear the overall responsibility for promoting the concept of an effective safety/survival program.
- They approve policies and procedures that are developed through cooperative efforts at other levels.
- They require, as a condition of employment, that all personnel learn and follow safety procedures and policies.
- They are responsible for ensuring adequate budget resources in terms of equipment, personnel, or other issues related to the funding and the support of your safety/survival program.
- They monitor the effectiveness of the program and communicate with regulatory agencies as required.



11.62 Safety Department Staff

- They coordinate and distribute safety requirements and regulations.
- They provide safety resources to all levels of the program.
- They coordinate safety activities with regard to agency insurance programs.
- They provide some form of facility safety inspections.
- They provide support for training and programs which might include audio-visual, equipment and materials, books, or other resources.
- They conduct ongoing evaluation of safety procedures with revisions as required based on recommendations and discussions with personnel at the operating level (the Safety Committee).

11.63 Manager, Supervisor, Field Personnel

This is the final level of responsibility, those actually involved in the day-to-day operation of the collection system.

As stated earlier, this is where all the action is and rightfully so, since this is where all of the expertise should be in terms of safety and survival. After all, we should be the ones who are most knowledgeable about how to safely perform our work and should not wait for somebody at the administrative level to tell us how they think it should be done.

Supervisors and managers who are involved in everyday collection system operations are critical to the success of the safety/survival program.

- They must be **aware** of safety rules and regulations that apply to each task.
- They are **responsible** for the safety of other personnel who work in or pass through their area of supervision.
- They are **responsible** for job safety instruction and new employee orientation.
- They are **responsible** for safety training within their area.
- They are **responsible** for identifying unsafe practices and conditions as well as taking adequate action to correct those within their authority.
- They should **investigate** injury-producing accidents and property damage accidents within their area of supervision.
- They must make a firm **commitment** to a safety/survival program in order to develop appropriate safety attitudes in personnel. Obviously, education, personal examples, and active participation in the program are essential to its success.
- They are **responsible** for promoting and enforcing the use of recommended personal protective equipment. They may be given fines and/or prison sentences if found negligent in any of the above areas that contributed to a fatal accident.

Field personnel are obviously the major factor in the success or failure of your program which will be measured by injuries, possible disability or death. The responsibilities of the operators in the field include:

- They are **RESPONSIBLE** for learning and following all safety procedures and policies.
- They must be willing to make a **COMMITMENT** to the safety/survival program and assume the **RESPONSIBILITY** to make the program a part of the daily routine. (Once again, it is in our best interest to make the program work since we are the ones who are normally involved in the injuries, disabilities, and fatalities.

Even if the other two levels in the safety program are not effective, you can have a major impact on the success of the program by participating at your level. Draw on your field experience to help develop or modify procedures and policies through an active safety committee. Encourage others at all levels to participate with you.

Disciplinary action can be an effective tool, if required, in maintaining safety policies and procedures. Note: No one should be expected to work with another operator who endangers their safety. Report dangerous field incidents to your immediate supervisor in writing. If you are placed in this type of situation, do not feel intimidated about reporting it.

SAFE OPERATIONS SHALL TAKE PRECEDENCE OVER EXPEDIENCY.

Operators must also participate in developing their own formal safety program which would include monthly meetings, a safety committee, and weekly tailgate sessions.

Tailgate sessions are short (ten minutes plus or minus) discussions that help focus on safety/survival as part of everyday, routine, collection system operator tasks. Topics can be specific to the job or related to home safety and seasonal events such as holidays. Virtually any topic that relates to safe practices will help inform operators and raise their level of awareness about safety.

An excellent resource for tailgate sessions is the American Water Works Association (AWWA) which publishes an annual series of 52 weekly safety talks.[5]

Some topics that are appropriate for a tailgate safety session include:

1. Safe and Economical Driving
2. Fire Prevention
3. Hand Tool Safety
4. Grounding Portable Tools
5. Productivity Versus Haste
6. Muscle Strains
7. Routing Traffic Around Work Sites
8. Manhole Entry
9. Calibrating and Using Atmospheric Testing Instruments
10. Life Line Safety Equipment
11. Personal Hygiene
12. Public Relations

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 312.

11.6A What are the responsibilities of "Top Administration" for a safety/survival program?

11.6B List the responsibilities for "Safety Department Staff" for a safety/survival program.

11.6C Supervisors and managers are involved in what aspects of a safety/survival program?

11.6D What are the responsibilities of operators in the field with regard to a safety/survival program?

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[5] *These are available from AWWA, Computer Services, 6666 West Quincy Avenue, Denver, Colorado, 80235, Order No. 70011. Price for each series for AWWA members, $11.50; nonmembers, $14.00.*

11.7 MONTHLY SAFETY MEETINGS

These meetings are more comprehensive than tailgate sessions and can last up to an hour or more, depending on the topic. Discussion topics may be of a general nature, but usually are more specific to the collection system work environment. Audio/visual presentations can be particularly effective if your safety department has a library and the essential equipment. Safety programs can be conducted either by operators or by employees of outside agencies. The following is a list of possible discussion topics.

TOPICS	PRESENTING PARTY
Gas Leaks	Local Gas Utility
Fire Fighting	Local Fire Department
Electrical Hazards	Local Electrical Utility
Back Injuries	Film and Safety Department
Slings & Material Handling Equipment	Equipment Supplier
Falling	Martial Arts - Private Company
SCBA Refresher	Safety Department
Confined Space	Operators
Right-To-Know	Training Department

Most suppliers of equipment, whether it be specific safety equipment or everyday hand tools, will assist you in organizing and conducting a monthly safety program.

Safety programs can be fun. Combine them with other events within the organization such as recognition events that recognize employees for length of service, exceptional work, or other achievements that are not necessarily related to safety. Audience participation meetings are very useful and can be combined with other methods. For example, set up teams and ask safety/work-related questions. Prizes could be awarded to individuals and the winning team and might range from silver dollars to savings bonds and gift certificates. Keep these meetings informal and arrange to provide coffee, donuts or other types of "goodies" if possible.

11.8 SAFETY COMMITTEE

An active committee staffed with operating personnel is another extremely effective tool in developing your safety/survival program. Depending on the nature of your organization, it could be comprised of the following:

- Representatives from each area of the collection system such as office personnel, electrical/mechanical maintenance, and operators.
- Representatives from other operating departments within your agency if you don't have a large enough collection system staff. Street, water, parks or other areas share many of the same safety/survival problems. Set up subcommittees to identify specific issues; for example, an equipment subcommittee might review and make recommendations on improving safety-related issues with the various equipment used. A policy/procedure subcommittee could also be established and would participate in developing/revising policy and procedures.

Members of the committee may be responsible for establishing a monthly program, which would include developing the resources. The resource personnel could be from your safety department or from an outside source, depending on the topic.

The Safety Committee reviews, analyzes and determines how each accident occurred and why. The Committee must recommend training procedures and distribute information to other workers to prevent similar accidents. If the injured worker was not paying attention or just plain careless, then better tailgate safety meetings are needed. If the accident resulted from an unsafe act, use of the wrong tool, or improper use of a piece of equipment, then training procedures need to be changed to correct the safety hazard. If new equipment or training aids are needed, the Safety Committee must identify these needs, justify them to the safety officer and management, acquire the necessary equipment and aids, and implement their use. The Safety Committee must consist of expert workers who know and can justify what is needed and not just request "stuff" and "things" because it sounds like a good idea.

11.9 SAFETY/SURVIVAL PROGRAM POLICIES

Safety policies are established to ensure that all operators understand and follow safe procedures at all times. The policies included here are typical examples of policies which should exist in your agency. These may not meet your local or state requirements, but can be used as a starting point to help you define your agency's policies. A good policy statement will clearly define the conditions under which it applies, the behaviors required of employees, and the penalty for failure to comply with the policy.

CONFINED SPACE POLICY

The purpose of this policy is to establish guidelines for personnel engaging in work that would require entry into structures, including those under construction, that fall under the definition of confined space.

The definition of a confined space used for this policy is: "A space which by design has limited openings for entry and exit; and/or natural ventilation which could contain or produce unfavorable atmospheric conditions; and is not intended or designed for continuous employee occupancy."

The types of confined spaces typically encountered in our work include, but are not necessarily limited to, sewer manholes, sewer lines, junction structures, valve vaults, metering vaults, pumping station wet wells, storage tanks, pits and silos.

All confined space work shall be performed with strict adherence to the "Confined Space Work Procedure." No one shall perform or order to be performed any work contrary to this procedure.

Failure to comply with this policy will result in disciplinary action.

LOCK-OUT POLICY

The purpose of this policy is to establish guidelines for personnel required to work on machinery or equipment in facilities owned and operated by this agency.

The definition of "work" on machinery or equipment used for this policy is: "maintenance, inspection, cleaning, adjusting, servicing, or clearing of blocked or jammed machinery or equipment."

All work shall be performed in strict adherence to the "Lock-Out Procedure." No one shall perform or order to be performed any work contrary to this procedure.

Failure to comply with this policy will result in disciplinary action.

EYE PROTECTION POLICY

The purpose of this policy is to establish guidelines for the wearing of eye protection devices.

All employees shall wear proper eye protection devices when working in any facility capable of producing eye injury, including those under construction where the environment may contain physical and/or chemical agents or radiation.

Proper eye protection devices shall consist of, but not necessarily be limited to the following: safety glasses with side shields, splash goggles, face shields, welding helmets and welding goggles, all of a type specifically approved by the Safety Officer. Contact lenses are allowed in office areas only, unless written approval is obtained from the Safety Officer.

All work performed shall be performed in strict adherence to the "Eye Protection Procedure." No one shall perform or order to be performed any work contrary to this procedure.

Failure to comply with this policy will result in disciplinary action.

SAFETY VEST POLICY

The purpose of this policy is to establish guidelines for the wearing of safety vests (warning vests).

All employees working on or within ten (10) feet of a roadway traveled by motorized vehicles shall be provided with and required to wear warning vests of high visibility. Warning vests will be bright orange in color with reflectorized material attached thereon, as approved by the Safety Officer.

The definition of a roadway used for this policy is: "That portion of a highway improved, designed or ordinarily used by vehicular traffic." The following areas shall be considered to fall under the classification of a roadway: freeways, highways, state roads, county roads, township roads, secondary roads, streets, alleys, drives, avenues, parkways or on the shoulders or berms, or on the median adjacent to roadways.

All work shall be performed in strict adherence to the "Safety Vest Policy." No one shall perform or order to be performed any work contrary to this policy.

Failure to comply with this policy will result in disciplinary action.

HARD HAT POLICY

The purpose of this policy is to establish guidelines for the wearing of hard hats.

All employees working on or in any agency facility, including those under construction, will be provided with and shall be required to wear a hard hat at all times. All hard hats shall be of a type specifically approved by the Safety Officer. Exceptions to this policy may be granted only by the supervisor, provided this exclusion has been reviewed and approved by the Safety Officer. (**Note:** Bump caps shall not be considered a substitute for hard hats.)

The possession and care of hard hats is the responsibility of each employee. Any defective or damaged hard hat shall be taken out of service immediately. The altering of hard hats in any way, manner, or form is strictly prohibited.

All work shall be performed in strict adherence to the "Hard Hat Policy." No one shall perform or order to be performed any work contrary to this policy.

Failure to comply with this policy will result in disciplinary action.

SEAT BELT POLICY

The purpose of this policy is to establish guidelines for the wearing of seat belts.

All employees occupying any agency vehicle, while in motion at speeds greater than 5 miles per hour, shall wear both the lap and shoulder safety devices at all times. (Note: Gas or electric carts, intended for in-plant use only, are excepted from this policy.)

All vehicles that have defective or otherwise inoperative safety belt devices shall be removed from service until the deficiency has been corrected.

Failure to comply with this policy will result in disciplinary action.

11.10 Records

Unfortunately accidents do happen in spite of all of our efforts. To prevent similar accidents from happening in the future, an "Accident Report" should be completed as soon as possible after an accident. Figure 11.4 is a typical "Accident Report."

11.11 Additional Reading

1. An excellent source of safety information is the

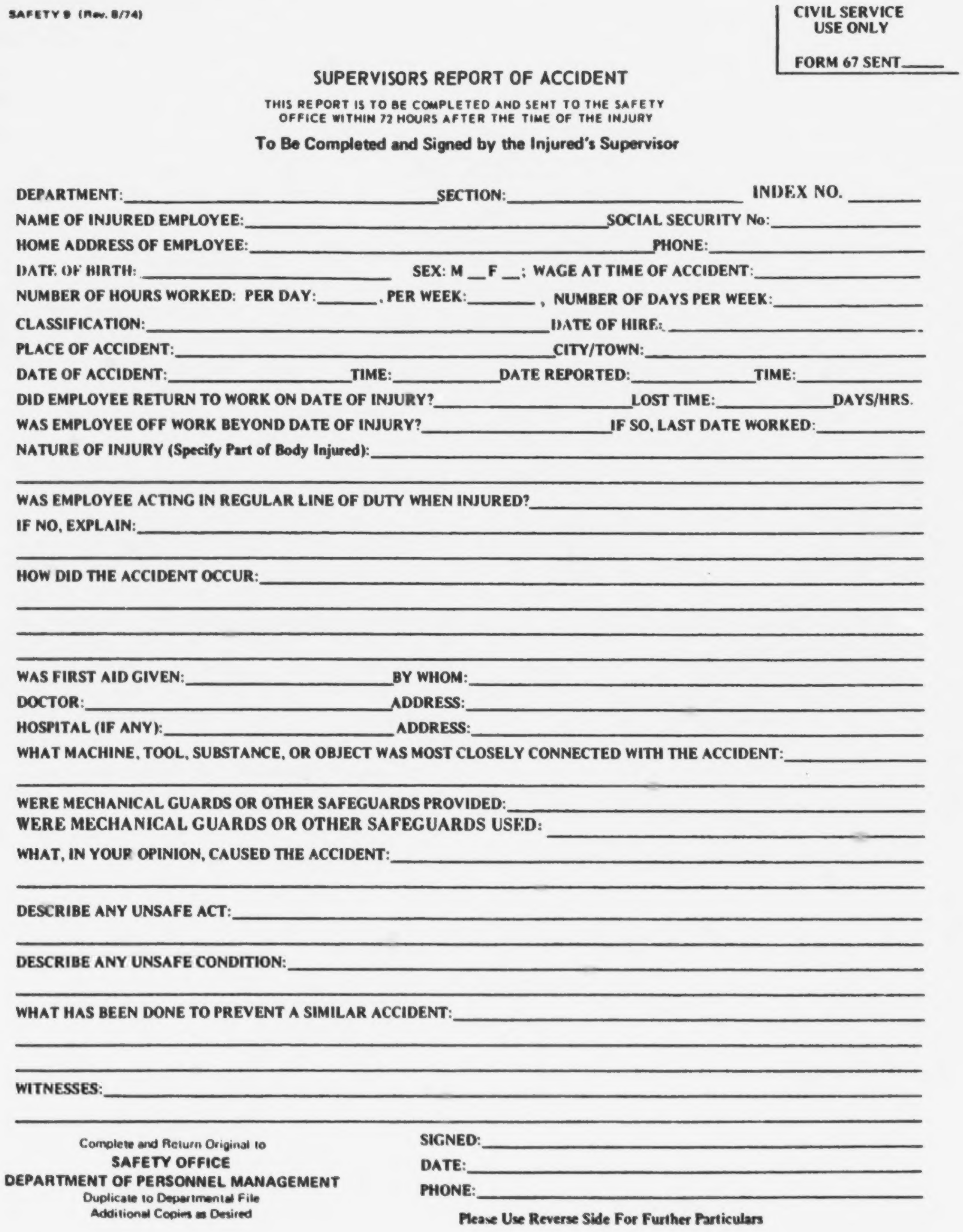
   Water Pollution Control Federation
   601 Wythe Street
   Alexandria, Virginia 22314-1994

   Important WPCF publications include

   a. *Safety and Health in Wastewater Systems, Manual of Practice* (MOP) No. 2. Order NO. M0010G0. Price for members, $19.00; nonmembers, $25.00.

   b. *Operation and Maintenance of Wastewater Collection Systems,* MOP 7. Order No. M0070G0. Price for members, $9.00; nonmembers, $12.00.

2. *SAFETY MANUAL,* California Water Pollution Control Association, PO Box 575, Lafayette, CA 94549.
3. *COMMON SENSE IN THE COMMON TRENCH,* by Red Cass. The Plank Company (West Coast Division), 8979 Elk Grove/Florin Road, Elk Grove, CA 95624. Price, $11.00.



SAFETY 9 (Rev. 8/74)

CIVIL SERVICE
USE ONLY

FORM 67 SENT____

SUPERVISORS REPORT OF ACCIDENT

THIS REPORT IS TO BE COMPLETED AND SENT TO THE SAFETY OFFICE WITHIN 72 HOURS AFTER THE TIME OF THE INJURY

To Be Completed and Signed by the Injured's Supervisor

DEPARTMENT:____ SECTION:____ INDEX NO.____
NAME OF INJURED EMPLOYEE:____ SOCIAL SECURITY No:____
HOME ADDRESS OF EMPLOYEE:____ PHONE:____
DATE OF BIRTH:____ SEX: M __ F __; WAGE AT TIME OF ACCIDENT:____
NUMBER OF HOURS WORKED: PER DAY:____, PER WEEK:____, NUMBER OF DAYS PER WEEK:____
CLASSIFICATION:____ DATE OF HIRE:____
PLACE OF ACCIDENT:____ CITY/TOWN:____
DATE OF ACCIDENT:____ TIME:____ DATE REPORTED:____ TIME:____
DID EMPLOYEE RETURN TO WORK ON DATE OF INJURY?____ LOST TIME:____ DAYS/HRS.
WAS EMPLOYEE OFF WORK BEYOND DATE OF INJURY?____ IF SO, LAST DATE WORKED:____
NATURE OF INJURY (Specify Part of Body Injured):____
WAS EMPLOYEE ACTING IN REGULAR LINE OF DUTY WHEN INJURED?____
IF NO, EXPLAIN:____
HOW DID THE ACCIDENT OCCUR:____
WAS FIRST AID GIVEN:____ BY WHOM:____
DOCTOR:____ ADDRESS:____
HOSPITAL (IF ANY):____ ADDRESS:____
WHAT MACHINE, TOOL, SUBSTANCE, OR OBJECT WAS MOST CLOSELY CONNECTED WITH THE ACCIDENT:____
WERE MECHANICAL GUARDS OR OTHER SAFEGUARDS PROVIDED:____
WERE MECHANICAL GUARDS OR OTHER SAFEGUARDS USED:____
WHAT, IN YOUR OPINION, CAUSED THE ACCIDENT:____
DESCRIBE ANY UNSAFE ACT:____
DESCRIBE ANY UNSAFE CONDITION:____
WHAT HAS BEEN DONE TO PREVENT A SIMILAR ACCIDENT:____
WITNESSES:____

Complete and Return Original to
SAFETY OFFICE
DEPARTMENT OF PERSONNEL MANAGEMENT
Duplicate to Departmental File
Additional Copies as Desired

SIGNED:____
DATE:____
PHONE:____

Please Use Reverse Side For Further Particulars

Fig. 11.4 Accident Report

4. *EXCAVATION AND TRENCHING OPERATIONS* (Title No. 689-601). A resource Supplement of OSHA 2091 by Occupational Health and Safety Administration, US Department of Labor. Entire kit of 139 slides and two books may be purchased for $60.00. National AudioVisual Center, 8700 Edgeworth Drive, Capitol Heights, MD 20743-3701.
5. "Plant Safety and Good Housekeeping," by Robert Reed, Chapter 14 in *OPERATION OF WASTEWATER TREATMENT PLANTS*, Volume II, Kenneth D. Kerri, California State University, Sacramento, 6000 J Street, Sacramento, California 95819. Price for Volume II manual, $25.00.
6. *A GUIDE TO SAFETY IN CONFINED SPACES*, DHHS (NIOSH) Publication No. 87-113. Available from National Institute for Occupational Safety and Health, Robert A. Taft Laboratories, 4676 Columbia Parkway, Cincinnati, Ohio 45226.
7. Contact other utility agencies (such as gas, electric and telephone) and find out what kind of safety programs they have that you can use. Their safety officers may be a good source for topic leaders on common problems or procedures.

11.12 Acknowledgment

The author of the safety chapter which appeared in the First and Second Editions was Mr. Glenn Davis. Many of the concepts developed by Mr. Davis in the original Chapter 10, "Safety Programs for Collection System Operators," have been included in this revised chapter.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 313.

11.7A How do monthly safety meetings differ from tailgate sessions?

11.8A Who should be on a "Safety Committee?"

11.9A What is the purpose of a confined space policy?

11.9B Define a confined space for the confined space policy.

11.9C What happens when an operator fails to comply with a safety policy?

11.10A Why should an accident report be prepared after every accident?

11.10B What information should be included in an accident report?

DISCUSSION AND REVIEW QUESTIONS

Chapter 11. SAFETY/SURVIVAL PROGRAMS FOR COLLECTION SYSTEM OPERATORS

Please answer these discussion and review questions before continuing. The purpose of these questions is to indicate to you how well you understand the material in the lesson. Write the answers to these questions before continuing with the Objective Test on page 313.

1. Why are the safety chapters the most important chapters in this entire course?
2. How do the three common factors generally missing when an accident occurs help prevent accidents?
3. Under what circumstances are falling objects a hazard to collection system operators?
4. How can operators minimize smashing knuckles and thumbs?
5. Who should work in or near explosive mixtures?
6. What toxic or poisonous gases may be found in collection systems?
7. How can an operator determine if an oxygen-deficient condition exists in a manhole?
8. Under what circumstances should a collection system operator *NOT* perform electrical work?
9. Why should operators share a larger portion of the responsibility for developing effective safety/survival practices?
10. What are the benefits from a safety/survival program?
11. What is a tailgate safety session?
12. What safety policies should be established by a collection system agency to ensure that all operators follow safe procedures?

SUGGESTED ANSWERS

Chapter 11. SAFETY/SURVIVAL PROGRAMS FOR COLLECTION SYSTEM OPERATORS

Answers to questions on page 299.

11.0A The three common factors that are important to prevent accidents are (1) AWARENESS, (2) RESPONSIBILITY, and (3) COMMITMENT.

11.1A The skill that most marks the professionalism of the collection system operator is the operator's ability to carry out work assignments safely.

11.1B The overall objective of this chapter is to make operators *AWARE* of the hazards of working in the collection system environment.

Answers to questions on page 301.

11.2A Hazards encountered by collection system operators in the performance of routine daily tasks and work assignments include (1) slips, (2) falling objects, (3) infections and infectious diseases, (4) lacerations and contusions, (5) falls, (6) explosions, (7) poisonous or toxic gases.

11.2B Slips and falls are most likely to occur when working in or around wet wells and metering flumes where slime can accumulate and surfaces are wet. When working in northern climates, snow, ice, and below-freezing temperatures can create slippery surfaces.

11.2C There has never been a recorded case of AIDS that can be attributed to working in the wastewater collection and treatment industry.

11.2D An explosion in a sewer can be set off by a spark from an automobile, an improper tool, or even a shoe nail, as well as the more obvious open flame or cigarette when the mixture of air and gas is within the level of the explosive limits.

11.2E Hydrogen sulfide gas is the gas most likely to be encountered because it is generated during the anaerobic decomposition of organic matter in wastewater. It is also the most dangerous gas because it is highly toxic and, being heavier than air, tends to collect in the bottom of confined spaces or underground structures.

Answers to questions on page 303.

11.2F An operator might encounter oxygen deficient atmospheres during the new construction inspection period inside pipelines and any time an operator is working inside confined spaces such as manholes, sewer lines and wet wells.

11.2G Traffic mishaps are a high risk area for collection system operators because access to a collection system is frequently from streets and roadways.

11.2H Collection system operators are most likely to find black widow spiders and scorpions in collection system facilities and structures such as manholes, metering enclosures and electrical control enclosures.

11.2I Permanent hearing loss can result if an operator is exposed to engine-driven pumps and standby power generators over a period of time unless adequate hearing protection is worn.

11.2J Collection system operator injury frequency rates were 4.5 times greater and severity rates were five times greater than the average rate for industrial workers in 1984.

Answers to questions on page 306.

11.3A Formal accident surveys do not accurately portray the severity of the problem because many agencies do not participate in the surveys.

11.4A The basis for a safety/survival program should be: **SAFE OPERATION SHALL TAKE PRECEDENCE OVER EXPEDIENCY OR SHORT CUTS.**

11.5A The three important levels of the structure within an agency for a safety program consist of the following:

1. Administration Department which states, "We will have a safety program";
2. Safety Department which says, "We will help with the resources"; and
3. Safety Committee which is "where the action is."

Answers to questions on page 307.

11.6A The responsibilities of "Top Administration" for a safety/survival program include (1) promotion of the concept, (2) approve policies and procedures, (3) require adherence to safety procedures, (4) ensure adequate budget resources and (4) monitor effectiveness of the program and communicate with regulatory agencies as required.

11.6B The responsibilities for "Safety Department Staff" for a safety/survival program include providing (1) safety resources, (2) facility safety inspections, (3) program support in terms of training, and (4) evaluation of safety procedures with revisions as required.

11.6C Supervisors and managers in a safety/survival program are involved in (1) an awareness of safety rules and regulations, (2) the safety of other personnel who work in or pass through their area of supervision, (3) job safety instruction and new employee orientation, (4) safety training within their area, (5) identifying unsafe practices and conditions and taking corrective action, (6) investigating injury-producing accidents and property damage accidents, (7) making a firm *COMMITMENT* to a safety/survival program, and (8) enforcing the use of personal protective equipment.

11.6D The responsibilities of operators in the field with regard to a safety/survival program include (1) understanding and following all safety procedures and policies, (2) making a *COMMITMENT* to the safety/survival program, and (3) assuming the *RESPONSIBILITY* to make the program a part of the everyday routine.

Answers to questions on page 311.

11.7A Monthly safety meetings are more comprehensive than tailgate safety sessions. Monthly meetings can last up to an hour or more, depending on the topic, as compared to ten minutes for tailgate safety sessions.

11.8A A "Safety Committee" could consist of representatives from each area of the collection system such as office personnel, electrical/mechanical maintenance, and operators. If the collection system staff is small, the committee could consist of representatives from other departments such as street, water, parks, and other areas which share many of the same safety/survival problems.

11.9A The purpose of a confined space policy is to establish guidelines for personnel engaging in work that would require entry into structures, including those under construction, that fall under the definition of confined space.

11.9B The definition of a confined space for the confined space policy is: "A space which by design has limited openings for entry and exit; and/or natural ventilation which could contain or produce unfavorable atmospheric conditions; and is not intended or designed for continuous employee occupancy."

11.9C When an operator fails to comply with a safety policy, disciplinary action will be the result.

11.10A An accident report must be prepared by the supervisor after every accident to prevent similar accidents from happening in the future.

11.10B Information that should be recorded in an accident report includes:

a. The location of the accident,

b. What the injured person did to cause the accident,

c. Identity of any other persons involved in the accident,

d. List of persons who saw the accident, and

e. Corrective action taken to prevent similar accidents.

OBJECTIVE TEST

Chapter 11. SAFETY/SURVIVAL PROGRAMS FOR COLLECTION SYSTEM OPERATORS

Please write your name and mark the correct answers on the answer sheet as directed at the end of Chapter 1. There may be more than one correct answer to the multiple choice questions.

1. The victims of collection system accidents and fatalities are usually
   1. Collection system operators.
   2. Consulting engineers.
   3. Line supervisors.
   4. Maintenance personnel.
   5. Safety department personnel.
2. What costs are directly related to the safety performance of a collection system agency?
   1. Disability insurance.
   2. Liability insurance.
   3. Maintenance costs.
   4. Salaries.
   5. Workers compensation rates.
3. High costs directly related to a poor safety performance will indirectly affect funds available for
   1. Equipment.
   2. Operation and maintenance.
   3. Salaries.
   4. Training.
   5. Workers compensation.
4. Reasons why neither collection system operators nor the medical profession suffer from an unusually high incidence of infection include that both
   1. Develop immunities to infectious diseases.
   2. Regularly breathe fresh air.
   3. See their physician frequently.
   4. Wash hands before eating.
   5. Work where the records reporting diseases may be inadequate.
5. Diseases or infections that collection system operators could come in contact with on the job include
   1. Dysentery.
   2. Infectious hepatitis.
   3. Roundworm.
   4. Smallpox.
   5. Venereal diseases.
6. Diseases that should be included in every collection system operator's immunization schedule include
   1. Cholera.
   2. Polio.
   3. Tetanus.
   4. Tuberculosis.
   5. Typhoid.

7. Sources or causes of explosions in collection systems include
   1. Flammable material discharges from industries.
   2. Infiltration from a waste gas burner.
   3. Leaks from underground hydropneumatic tanks.
   4. Natural gas leaks.
   5. Tank truck accidents.

8. Sources of poisonous or toxic gases in collection systems include
   1. Dumping of toxic chemicals.
   2. Infiltration of groundwater.
   3. Inflow from storm water runoff.
   4. Natural decomposition of organic solids.
   5. Reactions from two or more chemicals.

9. Back strains are most likely to occur when an operator is
   1. Driving a truck.
   2. Maneuvering equipment in tight places.
   3. Operating a lifting crane.
   4. Pulling a manhole cover.
   5. Using a manhole lifter.

10. Excavations deeper than _____ feet must have shoring.
    1. 1
    2. 2
    3. 3
    4. 4
    5. 5

11. The part of the collection system operator's body which is most likely to be injured is the
    1. Back.
    2. Foot.
    3. Hand.
    4. Head.
    5. Leg.

12. Costs associated with accidents include
    1. Damaged equipment and material.
    2. Loss of experienced operators.
    3. Lost work output.
    4. Prevention of human suffering.
    5. Training of new operators.

13. Responsibilities of "Top Administration" for a safety/survival program include
    1. Approving policies and procedures.
    2. Ensuring adequate budget resources.
    3. Investigate injury-producing accidents.
    4. Monitoring effectiveness of program.
    5. Promoting the concept.

14. Responsibilities of "Safety Department Staff" for a safety/survival program include
    1. Conducting facility safety inspections.
    2. Evaluating safety procedures.
    3. Providing safety resources.
    4. Revising safety procedures as required.
    5. Supporting program in terms of training.

15. Responsibilities of supervisors and managers for a safety/survival program include
    1. Correcting unsafe practices.
    2. Identifying unsafe practices.
    3. Investigating injury-producing accidents.
    4. Making a firm commitment to the program.
    5. Providing safety training within their area.

16. Responsibilities of operators in the field for a safety/survival program include
    1. Assuming the responsibility to make the program a part of the everyday routine.
    2. Following all safety procedures and policies.
    3. Investigating injury-producing accidents.
    4. Making a commitment to the program.
    5. Understanding all safety procedures and policies.

17. Types of confined spaces typically encountered by operators include
    1. Corporation yards.
    2. Manholes.
    3. Storage tanks.
    4. Valve vaults.
    5. Wet wells.

18. The definition of "work" on machinery used for a safety policy includes
    1. Cleaning.
    2. Inspecting.
    3. Maintaining.
    4. Observing.
    5. Servicing.

19. Eye protection may be provided by
    1. Contact lenses.
    2. Face shields.
    3. Hard hats.
    4. Splash goggles.
    5. Welding helmets.

20. Hard hats must be worn by operators when entering
    1. Construction sites.
    2. Lift stations.
    3. Manholes.
    4. Monthly safety meetings.
    5. Store rooms.

END OF OBJECTIVE TEST

CHAPTER 12

ADMINISTRATION

by

Neal R. Townley

Revised by

Steve Goodman

TABLE OF CONTENTS

Chapter 12. Administration

PAGE

OBJECTIVES 320

LESSON 1

12.0 Need for Effective Administration 321
12.1 Principles of Administration 321
12.2 Operating Plan 321
  12.21 Mission Statement 322
  12.22 Goals 322
  12.23 Objectives and Tasks/Procedures 322

LESSON 2

12.3 Personnel 325
  12.31 Calculating Personnel Requirements 325
  12.32 Employment 328
    12.321 Occupational Description 328
    12.322 Applications 330
    12.323 Selection 332
    12.324 Employee Orientation 332
    12.325 Probationary Period 333
  12.33 Compensation 333
    12.331 Salaries 333
    12.332 Benefits 333
    12.333 Adjustments 333
  12.34 Training, Informing, and Certification 334
    12.341 Training 334
    12.342 Informing 335
    12.343 Certification 335

12.35 Employee Relations 335
    12.351 Negotiations 335
    12.352 Contracts 335
    12.353 Grievances 336
12.36 Safety 336
    12.361 Policy Statement 336
    12.362 Responsibilities 337
    12.363 Training and Promotion 337
    12.364 Accident Investigations 337

LESSON 3

12.4 Equipment and Tools 338
    12.41 Basis for Requirements 338
        12.411 Equipment Tailored to Program 338
        12.412 Efficient Use 339
    12.42 Lease, Purchase, or Contract 339
        12.421 Advantages of Leasing 339
        12.422 Advantages of Purchasing 340
        12.423 Advantages of Contracting 340
    12.43 Equipment and Tool Requirements 340
        12.431 Vehicles 340
        12.432 Special Equipment 341
        12.433 Miscellaneous Equipment and Tools 342
        12.434 Safety Equipment 344
        12.435 Office Equipment 346
    12.44 Management 347
        12.441 Inventory 347
        12.442 Responsibility 347
        12.443 Preventive Maintenance and Repair 347
        12.444 Replacement 347

LESSON 4

12.5 Facilities 348
    12.51 Yard 348
        12.511 Storage and Servicing Equipment 348
        12.512 Storage of Materials 349
        12.513 Training Areas 349
        12.514 Security 349

. 349
12.52 Shop 349
    12.521 Location 349
    12.522 Equipment 349
    12.523 Use 349
12.53 Operator Facilities 349
    12.531 Hygienic Facilities 350
    12.532 Assembly Room 350
    12.533 Employees' Room 350
12.54 Offices 350
    12.541 Location 350
    12.542 Types 350
    12.543 Ancillary Facilities 351
12.55 Landscaping 351
12.56 Parking 351
12.57 Design . . . .
LESSON 5 352
12.6 Mapping 352
  12.61 Importance of Mapping 352
  12.62 Information on Maps 352
    12.621 Locations 352
    12.622 Identifications 353
    12.623 Elevations and Depths 353
    12.624 Lengths and Widths 353
    12.625 Other Information 353
    12.626 Optional Information 354
  12.63 Type and Size of Maps 354
  12.64 Mapping Coordinates 356
  12.65 Examples of Mapping 356
  12.66 Preparation and Revision 356
    12.661 Preparations 356
    12.662 Revisions 362
  12.67 Microfiche Copies 362
  12.68 Maps as Maintenance Records . . . .

LESSON 6

12.7 Management Information Systems 363
- 12.71 Need 363
- 12.72 Definition 363
- 12.73 Data Processing with Microcomputers 364
  - 12.731 How Computers Work 364
  - 12.732 Computer Applications 364
  - 12.733 Specialty Software 364
- 12.74 Work Reports 366
  - 12.741 Need for Work Reports 366
  - 12.742 Types of Work Reports 366
  - 12.743 Retention of Reports 375
- 12.75 Records 375
  - 12.751 Need for Records 375
  - 12.752 Types of Records 378
  - 12.753 Retention of Records 382
  - 12.754 Responsibility for Records 383
- 12.76 Reports for Planning and Controlling 384
  - 12.761 Need for Reports 384
  - 12.762 Types and Forms of Reports 384
- 12.77 Work Directives 386
  - 12.771 Need for Directives 386
  - 12.772 Types of Directives 386

LESSON 7

12.8 Report Writing 390
- 12.81 Why You Need to Write Reports 390
- 12.82 How to Prepare a Report 390

12.9 Public Relations 392
- 12.91 Importance of Public Relations 392
- 12.92 Aspects of Public Relations 392
- 12.93 Benefits of Good Public Relations 393

12.10 Additional Reading 394

SUGGESTED ANSWERS 396

OBJECTIVE TEST 402

OBJECTIVES

Chapter 12. ADMINISTRATION

Following completion of Chapter 12, you should be able to:

1. Explain the need for effective administration,
2. Develop the goals, tasks and procedures for an operating plan,
3. Prepare and justify staffing and equipment requirements for your program,
4. Determine whether a piece of equipment should be leased or purchased,
5. Hire new operators,
6. Administer your agency's safety program,
7. Determine the facility requirements for your program,
8. Read the various types of maps used by collection system operators,
9. Explain the importance of and need for maps,
10. Keep maps up-to-date,
11. Determine the management information system requirements for your program,
12. Prepare and maintain records essential for budgeting, scheduling and meeting legal requirements,
13. Write an informative report, and
14. Organize an effective public relations program for your agency.

CHAPTER 12. ADMINISTRATION

(Lesson 1 of 7 Lessons)

12.0 NEED FOR EFFECTIVE ADMINISTRATION

The quality of the operation and maintenance of a wastewater collection system depends, to a great extent, on effective administration of the numerous elements involved in such a program. An effective administration will assure an operation and maintenance program that will keep a wastewater collection system functioning at its top efficiency, maximize its useful life, and minimize costs.

Personnel actually performing the operation and maintenance work will respect an effective administration, work more efficiently, and derive greater job satisfaction, thus providing for the retention of good personnel.

12.1 PRINCIPLES OF ADMINISTRATION

In 1916, Henri Fayol, an executive for fifty-eight years in a large French coal-steel combine, laid down fourteen basic administrative principles that are still valid today. These principles are:

1. **Division of work.** Specialization is necessary for maximum effectiveness.
2. **Authority.** A manager has the right to give orders and the power to compel obedience. One must make a distinction, however, between a manager's official authority and 'personal' experience, moral worth, and ability to lead.
3. **Discipline.** Obedience, application, energy, respect, and behavior go together to make up discipline — an essential condition for a smooth-running organization.
4. **Unity of command.** Whatever the action, an employee should receive orders from one superior only.
5. **Unity of direction.** A group of activities must have the same major purpose — one head and one plan. This condition is essential to unity of action, to coordination of strength, and to the focusing of effort.
6. **Subordination of individual interest to general interest.** This is a basic requirement in every well managed organization.
7. **Remuneration of personnel.** Payment and awards should be fair and should afford satisfaction to employees and the firm.
8. **Centralization.** This is a matter of finding the optimum degree of centralization for particular organizations. Centralization per se is neither good or bad; and the degree of centralization must vary in different cases.
9. **Scalar chain.** This term refers to the chain of superiors in an organization, ranging from the ultimate authority to the lowest ranks. Both orders and communications must flow along this chain. To depart needlessly from the line of authority is an error; but it is an even greater one to keep it when it is detrimental.
10. **Order.** It is a basic requirement for sound management.
11. **Equity.** Equitable treatment for employees is fundamental to good management. It is based on kindness and on justice.
12. **Stability of tenure of personnel.** Sound management requires stability of managerial personnel and employees. Constant change and turnover adversely affects the organization.
13. **Initiative.** A progressive managerial climate promotes initiative. It is a powerful stimulant to human endeavor. Encourage it and promote its development fully. A manager who is able to permit the exercise of initiative on the part of subordinates is infinitely superior to one who cannot do it.
14. **Esprit de corps.** In union there is strength. Promote it always. Avoid creating dissension among subordinates. Encourage and reward employees on the basis of their ability, talent, and accomplishment.

Fayol insisted that these principles were not rigid and should be applied in an intelligent manner.

12.2 OPERATING PLAN

An essential part of an effective administration is a detailed, written plan for the operation and maintenance of the wastewater collection system. The plan should consist of a statement of the agency's overall mission, goals to be attained and the specific objectives, tasks and procedures that will lead to attainment of the mission. The plan should be prepared by the manager of the organization responsible for operation and maintenance of the collection system with the full participation of the organization's personnel. The more clearly and completely the plan is put down in writing, the better agency personnel will be able to work in accordance with it. For any long-range plan to work, it is essential that the personnel who will implement it be involved in developing the plan and be generally supportive of it.

12.21 Mission Statement

The mission statement of an organization is a very broad, general explanation of the reason for the organization's existence. Such a statement might read:

> "The Clearwater Wastewater Collection Agency will provide safe, reliable, efficient collection system services at a minimum cost to the community of Clearwater, U.S.A."

This one sentence tells us who will do what for whom, and in what manner. It is the "ideal" that the agency strives to achieve. Once the basic purpose of an organization is defined, it will then be possible to develop a plan to accomplish this mission.

12.22 Goals

The Water Pollution Control Federation's Technical Task Force on Sewer Maintenance published[1] the following list of goals for the responsible and efficient management of a collection system. The goals are as follows:

1. Prevent public health hazards;
2. Minimize inconveniences by responsibly handling interruptions in service;
3. Protect the large investment in collection systems by maintaining maximum capacities and extending their useful life;
4. Prevent unnecessary damage to public and private property;
5. Use the funds available for the operation of municipal government services in the most efficient manner;
6. Convey wastewater to treatment facilities with a minimum of infiltration, inflow, and exfiltration;
7. Prevent excessive expenditures for claims and legal fees due to backup by providing immediate, concerned, and efficient service to all emergency calls; and
8. Perform all operations in a safe manner to avoid personal injury.

You should realize that full attainment of goals is difficult to reach. Just as in a football game, the real sense of accomplishment derives from the progress you make towards meeting a goal in spite of the difficulties and occasional setbacks you may experience.

12.23 Objectives and Tasks/Procedures

Once goals have been established, a plan for operation and maintenance of a collection system should outline the more specific objectives as well as tasks and procedures for progressing toward the desired goals. Let's assume your agency agrees that the goals set forth by the Water Pollution Control Federation are worthy of adoption. The following list demonstrates how you or your agency might go about setting specific objectives to meet each goal and how to list detailed tasks/procedures that will lead to accomplishing the objectives.

GOALS

1. Prevent public health hazards.
    a. Provide immediate, concerned and efficient service to all emergency calls.
        - Dispatch crews within one hour in response to emergency service calls.
        - Clean up and disinfect flooded homes.
    b. Assign scheduling priority to stoppages, overflows, and exfiltration that contaminates the environment.
        - Send supervisor to evaluate emergency calls.
    c. Use clean water to flush contaminated surfaces and disinfect with chemicals approved by the health authority.
        - Maintain a neat work area for repair and maintenance activities.
2. Minimize inconveniences by responsibly handling interruptions in service.
    a. Respond immediately to reports of sewer stoppages and remove them.
        - Sign priority status for removal of stoppages.
        - Dispatch crew within one hour of receiving emergency call.
    b. Use radios and 24-hour communications to dispatch personnel and mechanical equipment to remove sewer stoppages.
        - Equip emergency crew vehicles with 2-way radios.
    c. Keep system maps up-to-date.
        - Establish a routine for submitting map changes to drafting department.
        - Field check maps for accuracy.
3. Protect the large investment in collection systems by maintaining maximum capacities and extending their useful life.
    a. Inspect the collection facility to determine maintenance needs.
        - Use aids such as closed-circuit television to systematically inspect sewer lines and appurtenances.
        - Use depth and velocity measurements to determine flow of wastewater in sewer lines.
    b. Schedule and perform cleaning of sewer lines
        - Use high velocity cleaners or balling equipment as appropriate.
    c. Chemically treat sewers to inhibit root growth.
        - Use flooding or foaming methods.
    d. Inhibit release of hydrogen sulfide gas.
        - Apply chemicals to reduce rate of gas production.
        - Keep sewers clean to prevent deposition and accumulations of solids.
    e. Rehabilitate worn parts of collection facility when work will economically retain the capacity and extend the life of the part.
        - Develop a priority listing of areas needing rehabilitation.
        - Evaluate rehabilitation alternatives for each situation.
4. Prevent unnecessary damage to public and private property.
    a. Remove standing water and solids in buildings, grounds and streets resulting from stoppages in any part of the collection system.
        - Clean up areas affected by wastewater overflows using vacuum equipment and mops.
        - Remove waterlogged materials that would cause additional damage to a flooded building.
    b. Restore private property to its former condition when

---

[1] *OPERATION AND MAINTENANCE OF WASTEWATER COLLECTION SYSTEMS, page 2, Water Pollution Control Federation, 601 Wythe Street, Alexandria, Virginia 22314-1994.*

maintenance work had disturbed landscaping or fencing.
    - Work with homeowners.
  - c. Respond promptly to reports of stoppages and take appropriate corrective measures.
    - Be prepared to respond quickly to any expected type of stoppage.

5. Use funds available for the operation of municipal government services in the most efficient manner.
  - a. Prepare budgets for operation and maintenance of the collection system.
    - Establish a cost accounting system to track expenditures and maintenance costs.
    - Analyze previous year's costs for personnel, maintenance and equipment.
    - Estimate the cost of carrying out the planned tasks for the budget year.
  - b. Use budget and other expenditure controls to minimize the cost of operation and maintenance.
    - Determine who has authority to authorize purchases.
    - Implement a purchase order system.
    - Set up guidelines for examining alternative suppliers to obtain lowest possible prices.
  - c. Invest funds in interest-bearing securities when they are not immediately needed for operation and maintenance.
    - Analyze cash flow requirements for operation and maintenance based on maintenance schedules and past experience of fixed expenditures.
    - Invest excess available in interest-bearing securities.
    - Use or reinvest income earned on securities investment.

  - d. Influence the design and construction of the wastewater collection facility to ensure efficient, workable design.
    - Operating personnel participate in the design and construction inspection of the collection system.
    - Walk through planned construction sites to evaluate potential problems.
    - Research the merits of new technology for possible use in the system.

6. Convey wastewater to treatment facilities with a minimum of infiltration, inflow and exfiltration.
  - a. Remove sources of infiltration, inflow and exfiltration from the collection system.
    - Rehabilitate or repair worn and damaged parts of the collection system.
    - Reline corroded sewer lines and manholes.
    - Replace broken parts of sewer lines and mechanical equipment.
  - b. Isolate manhole and cleanout openings from surface water.
    - Plug holes in manhole covers.
    - Smoke test system to identify sources of surface water inflow.
  - c. Adopt and enforce sewer-use regulations prohibiting the discharge of storm or groundwater to the wastewater collection system.
    - Smoke test system.
    - Assign crews to search for illegal connections in problem areas.

7. Prevent excessive expenditures for claims and legal fees due to backups.
  - a. Dispatch crews within one hour in response to emergency calls for service.

  - b. Minimize damage caused by overflow water from the collection system by taking prompt action to:
    - Clean up areas affected by wastewater overflows using vacuum equipment and mops and disinfect as appropriate.
    - Remove waterlogged materials that would cause additional damage to a flooded building.
  - c. Keep complete records of all actions taken in the course of making repairs.
    - Require crews to promptly submit written reports detailing actions and procedures used.
  - d. Assist in the determination of appropriate compensation for damage caused by wastewater from the collection system.
    - Take photographs and make comprehensive reports on wastewater overflows and other accidents attributable to the operation and maintenance of the collection system.
    - Be prepared to give truthful and accurate information on how an incident occurred.

8. Perform all operations in a safe manner to avoid personal injury.
  - a. Take actions that consistently promote safe operation by personnel and contractors.
    - Promote safety by personal use of safe practices.
    - Provide safety equipment and require its use.
    - Require adherence to safe work practices.
    - Establish a written safety policy.
    - Reward personnel for safe practices and discipline personnel for unsafe practices.

  - b. Establish safety training programs for personnel.
    - Provide the time, qualified persons, and material for training personnel in the safe performance of their duties.
    - Construct specialized training facilities.
  - c. Control the risks involved in the operation and maintenance of the collection system.
    - Analyze planned operations for exposure of persons to injuries and prescribe appropriate safety procedures.
    - Immediately stop anyone observed performing an unsafe act.
    - Provide for safe storage of equipment and supplies.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 396.

12.1A What factors make up discipline?

12.2A What are the essential elements of an effective administrative plan?

12.2B How can a collection system agency work towards a goal of operating the system safely?

12.2C How can excessive infiltration and/or exfiltration be reduced?

12.2D How can management promote safety?

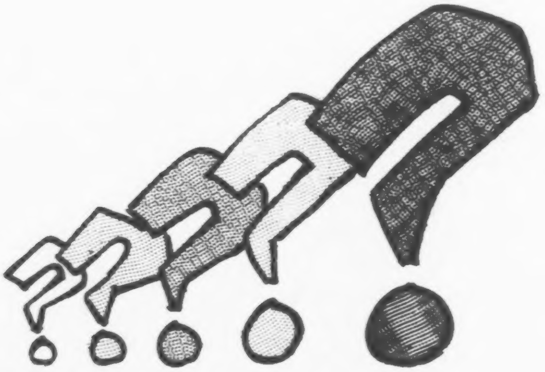
DISCUSSION AND REVIEW QUESTIONS

Chapter 12. ADMINISTRATION

(Lesson 1 of 7 Lessons)

At the end of each lesson in this chapter you will find some discussion and review questions that you should answer before continuing. The purpose of these questions is to indicate to you how well you understand the material in the lesson. Write the answers to these questions in your notebook before continuing.

1. What will an effective collection system administration accomplish?
2. How will personnel actually performing the operation and maintenance of a collection system respond to an effective administration?
3. Who should prepare an administrative plan?
4. How can a collection system agency work towards a goal of preventing unnecessary damage to public and private property?
5. How can a collection system agency work towards a goal of using funds efficiently?



CHAPTER 12. ADMINISTRATION

(Lesson 2 of 7 Lessons)

12.3 PERSONNEL

An effective administration will develop standardized and equitable procedures for the application, selection, orientation and training of personnel. Experience and careful planning will enable you to project how large a staff will be needed to operate and maintain your wastewater collection system and to meet your goals and objectives. It is always easier to employ additional personnel as their need is demonstrated rather than to fire excess personnel.

12.31 Calculating Personnel Requirements

The most important factor influencing the number of personnel needed to maintain a wastewater collection system is its size. The following factors also influence personnel requirements:

Age - Older systems generally require more maintenance.

Condition - Systems poorly constructed and abused in the past by neglect will require more maintenance than a system in good condition.

Climate - Frequent rain and snow storms will reduce the operators' production rates and this will have to be offset by additional personnel.

Building Services - Maintenance of building services, when performed by collection system staff, will require additional personnel.

Work Rates - The rate of work produced by cleaning, repair and inspection crews (which is influenced by motivation, training, equipment, travel distance and conditions) will affect the number of personnel required for maintenance of a collection system.

Storm Sewers - If an agency maintains storm sewers in addition to a wastewater collection system, additional personnel will be required.

Funding - The amount of funds available for maintenance of a collection system may be a temporary constraint on the number of personnel. However, an effective administrator should eventually be able to secure adequate funding for an appropriate maintenance program by documenting system needs and presenting well-thought-out budget proposals.

Topography - Sewers with steep slopes may require erosion repairs and special cleaning procedures; sewers on flat terrain may have greater deposition of solids and lift stations that will require greater maintenance; and sewers submerged in groundwater may require more frequent sealing.

Safety - An administration seriously committed to safe working conditions and safe operating procedures will require additional staff time for safety training, enforcement of safety policies and adequate crew staffing to ensure worker safety.

Two manuals entitled *MANPOWER REQUIREMENTS FOR WASTEWATER COLLECTION SYSTEMS IN CITIES AND TOWNS UP TO 150,000 INPOPULATION and MANPOWER REQUIREMENTS FOR WASTEWATER COLLECTION SYSTEMS IN CITIES OF 150,000 TO 500,000 IN POPULATION,* listed as additional reading at the end of this chapter, provide additional guidelines for determining personnel requirements and include tables, numbers and classification of maintenance personnel based on a 1973 survey of 49 U.S. cities. Any charts or formulas for determining personnel requirements should be used only as a guideline since personnel requirements for each collection system will be different and dependent on the factors listed above.

For the purpose of illustrating how to determine personnel requirements, let us again refer to our typical town, Clearwater, USA. The new superintendent, whom we'll call Carl, was told that the collection system had been somewhat neglected and that he was to prepare a plan for expanding and reorganizing the maintenance department to meet the goals previously set forth in this chapter. The new superintendent spent many hours reviewing records, maps,crew activities at various sites, and held lengthy discussions with the work supervisors.

Assume Clearwater (our typical town) originated in the late 1800's. The downtown area is located adjacent to a river with rolling hills on both sides. Clearwater has a population of 180,000 people and an industrial base equivalent to an additional 25,000 persons. The Publicly Owned Treatment Works (POTW) consists of the collection system, intercepting sewers, sixteen wastewater lift stations, and a secondary treatment plant with a design capacity of thirty million gallons per day.

The new superintendent hired by the Director of the Department of Clearwater Public Works will be responsible for field activities of the Wastewater Collection Division. The wastewater treatment plant is part of the division, but has its own superintendent to oversee its operations. During orientation to the new position, the collection system superintendent is given the following information.

1. Clearwater assumes responsibility for the wastewater-collection system to five feet past the property line, or to a property line cleanout.
2. Overflows, spills, or raw wastewater by-passes must be reported to the following:
   a. Regional Pollution Control Agency,
   b. Local Health Department, and
   c. Director of Public Works.
3. Supplies and equipment must be obtained through the Clearwater City purchasing department.
4. Personnel management practices must be in accordance with rules prescribed by the Clearwater personnel department.
5. Sewer-use ordinance enforcement will be part of the section's function, with support from the wastewater treatment plant for required laboratory analysis.
6. All funding for section activities must be budgeted.
7. Superintendent is responsible for planning and implementing maintenance, operation, training, and safety aspects of the section.
8. Department of Public Works' staff engineers provide support for design work or technical engineering when required. Work requests must be in writing on department work request forms.

The superintendent's own review of agency records, maps, and the physical system itself provided the following information.

1. Clearwater collection system pipelines — total length, 760 miles, including the following estimated lengths:
   a. 311 miles of 4-inch building service lines,
   b. 167 miles of 6-inch sewers,
   c. 80 miles of 8-inch sewers,
   d. 48 miles of 10-inch sewers,
   e. 17 miles of 12-inch sewers,

   f. 137 miles of intercepting sewers ranging from 15 to 60 inches in diameter,
   g. 7,900 manholes, and
   h. 54,700 building sewer connections.
2. Wastewater lift stations
   a. Number of stations, 16.
   b. All stations telemetered with failure alarms. Cause of failure is not indicated — only that station is malfunctioning. Police Department switchboard monitors lift station alarm system during off-duty hours and weekends.
3. General condition of system
   a. Unknown due to lack of history and systematic inspection — need to inspect using TV system.
4. Known problem areas in system
   a. Excessive infiltration/inflow during storms in older portion of city.
   b. Power rodding activity indicates significant root problem in northwest suburban area.
   c. High velocity cleaner activity indicates excessive grease buildups in area with restaurants.
   d. Treatment plant superintendent reports high volume of grit removal at treatment plant, especially during storms. Also plant superintendent reports heavy solids and organic loading at random times and that the suspected source is the XX industrial plant.
   e. No enforcement of sewer-use ordinance.
   f. Lift stations are in poor mechanical condition and cleaning procedures need improvement.
   g. Main line stoppages are averaging three per day.
   h. Service request calls are averaging 10 per day (mostly obnoxious odors and stoppages).

Superintendent Carl is now thoroughly familiar with the collection system facilities and problems, has developed a list of goals and objectives to meet the agency's overall mission, and is now ready to develop the detailed plan of exactly how the system's resources will be used to accomplish its goals. This activity is as much a juggling act as anything and requires both skill and experience. Carl begins by listing all of the O & M direct work activities (Column 1 of Table 12.1). Similarly, he starts another list of indirect activities his staff will be involved in (Column 1 of Table 12.2).

The next step is to weigh the importance of each of the goals he has set. The new superintendent's highest priority for the coming year is to reduce main line stoppages from the present 1000+ to approximately 300. To do this, operators' efforts will be concentrated on specific tasks such as balling and high velocity cleaning of major portions of the collection system. Areas where root stoppages are occurring frequently will require a chemical root control program. The grease stoppages in the sewers near the restaurant area of downtown demand that sewer cleaning activities in this area be increased.

Superintendent Carl also has to decide how much work will need to be done on the other system components to keep the system functioning smoothly and to move ahead in preventive maintenance. This is where his experience and judgment will be invaluable. Once he has estimated these work levels (Columns 3 and 4 of Table 12.1 and Column 2 of Table 12.2), the superintendent must figure out how many staff hours each task will take. To do this, he will look first at work rates for direct activities (Column 5, Table 12.1).

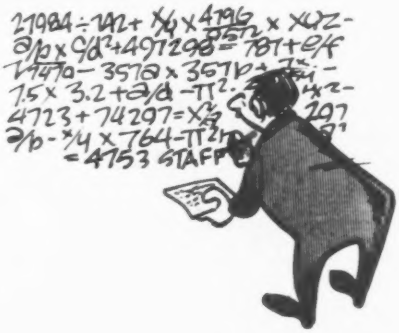


TABLE 12.1 DIRECT TIME FOR MAINTENANCE OF CLEARWATER WASTEWATER COLLECTION SYSTEM

WORK ACTIVITY	TOTAL SYSTEM UNITS	PERCENT TO BE ACTED ON	ANNUAL WORK QUANTITY	WORK RATE	ANNUAL STAFF DAYS
Cleaning:					
Balling	1,789.920 ft	25	447,480 ft	130 ft/shr*	430.3
High Velocity	1,789,920 ft	60	1,073,952 ft	300 ft/shr	447.5
Bucketing	580,800 ft	5	29,040 ft	10 ft/shr	363.0
Flushing	881,760 ft	8	70,541 ft	610 ft/shr	14.5
Rodding					
Scheduled	1,980,000 ft	10	198,000 ft	90 ft/shr	275.0
Main Stoppage			295 ea	0.3 ea/shr	122.9
Bldg Stoppage			1,270 ea	0.6 ea/shr	264.6
Repairing and Replacing:					
Main Breaks	2,370,720 ft	0.1	2,371 ft	0.4 ft/shr	987.9
Joint Sealing	2,370,720 ft	0.1	2,371 ft	8.0 ft/shr	49.4
Lining	2,370,720 ft	0.1	2,371 ft	6.0 ft/shr	74.1
Manholes	7,900 ea	10.0	790 ea	0.5 ea/shr	197.5
Lift Stations	16 ea	1,200.0	192 ea	0.2 ea/shr	120.0
Building Sewers	54,700 ea	1.0 mo	547 ea	0.2 ea/shr	341.9
Inspection and Control:					
Manhole Inspections	7,900 ea	50	3,950 ea	2.0 ea/shr	329.9
TV Inspections	2,370,720 ft	10	237,072 ft	50.0 ft/shr	592.7
Infil/Infl Investigations	7,900 ea	10	790 ea	1.0 ea/shr	98.8
Chemical Treatment	7,900 ea	10	790 ea	1.0 ea/shr	98.8
Lift Station Inspections	16 ea	5,200	832 ea	0.5 ea/shr	208.0
Industrial Waste Inspections	2,500 ea	33	825 ea	1.0 ea/shr	103.1
Total Direct Time					4,752.7

*shr = staff hours

TABLE 12.2 INDIRECT TIME FOR MAINTENANCE OF CLEARWATER WASTEWATER COLLECTION SYSTEM

ACTIVITY	PERCENT OF TOTAL TIME	TOTAL TIME* (STAFF DAYS)	ANNUAL INDIRECT STAFF DAYS
Equipment Servicing	5	6,422.9	321.1
Building and Grounds	3	6,422.9	192.7
Maintenance Work for Other Departments	1	6,422.9	64.2
Training	5	6,422.9	321.1
Leave and Holidays	12	6,422.9	770.7
Total	26		1,669.8

*Total Time = $\frac{4.753}{0.74}$

= 6,422.9

The superintendent's estimated work rates for each of the listed activities are based on discussions with superintendents of other collection systems, analysis of annual reports, and Carl's own estimate of how the information applies to the Clearwater collection system. He expects to modify the work rates as appropriate once he has an opportunity to analyze the actual work records of his division.

To calculate the number of staff days needed to complete the annual plan of direct work, the superintendent divided the estimated work rates into the proposed work quantities; then he divided the results by eight staff hours per day. For example, Carl estimates that a balling crew can clean 130 feet of line per person per hour. To clean 25 percent of the system's lines by balling, it will take 430.3 staff days (447,480 ft ÷ 130 ft/hr ÷ 8 hr/day = 430.3 staff days).

The superintendent again used the sources of information previously described to estimate the amount of time collection system operators will spend on indirect work activities and annual leave (Column 1, Table 12.2). Column 2 of Table 12.2 shows us that 26 percent of the operators' time will be spent on indirect activities. To find out how many staff days that represents for each activity, Carl must do some additional calculations. He must first find out the total number of staff days that will be spent on both direct and indirect activities combined. The procedure for making this calculation is:

KNOWN	UNKNOWN
Total staff days for direct activities = 4,753	Total staff days for direct and indirect activities combined
Percentage of staff days for indirect activities = 26%	
Percentage of staff days for direct activities = 74%	

FORMULA:

$$\frac{74\%}{100\%} = \frac{4753}{X}$$

$$X = 6{,}422.9$$

Knowing now that it will take a total of 6,423 staff days to conduct the planned preventive maintenance program during the next fiscal year, Carl can now compute the number of annual indirect staff days for each activity (Column 4, Table 12.2).

The last calculation Carl needs to make, and a very important one it is, will be determining how many operators are needed to perform 6,423 staff days of work. Since there are 260 staff days per year (52 weeks x 5 staff days), dividing the total estimated staff days by 260 reveals that it will take 25 (6,423/260 = 25) collection system operators to perform the planned maintenance work.

In addition, the superintendent decided to have eight staff personnel (in addition to himself) to assist in administering the maintenance program. Therefore, the budget for the next fiscal year would provide for a total of 33 persons in the Wastewater Collection Division. Chapter 13 will describe how the superintendent organized the division's personnel.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 396

12.3A Overflows, spills, or raw wastewater by-passes must be reported to whom by the Clearwater superintendent?

12.3B What are the responsibilities of Clearwater's superintendent?

12.3C What items would you consider if you summarized a wastewater collection system?

12.32 Employment

The superintendent of a wastewater collection system will usually have the assistance of the agency's personnel department in the selection and employment of personnel. However, since the personnel will be working under the superintendent's direction and since the superintendent will be responsible for their performance, it is important that the superintendent be involved in the employment process. Selection of personnel is important since it is often difficult to fire an employee and the agency will lose the investment made in the employment and training of the person.

12.321 Occupational Description

The superintendent should assist the personnel department in the preparation of an occupational description for each of the persons working in the department or division. The following is a typical occupational description:

> Title: **MAINTENANCE PERSON II, WASTEWATER COLLECTION**[2]
>
> Repairs and maintains municipal storm and sanitary sewer lines, functioning as a lead person and performing any combination of following tasks: Inspects manholes to determine location of stoppage. Runs rod through rod guide, fits front end of rod with auger, using wrench, and lowers guide into position. Thrusts rods into invert and advances them until auger reaches obstruction. Rotates rods manually with turning pin or attaches end of rod to portable power rodder to rotate rods. Pulls lever and depresses pedal of machine to advance cleaning tool slowly until it encounters obstruction and to rotate cable or rods until obstruction is broken. Retracts rods to drag

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[2] *Adapted from page 68, MANPOWER REQUIREMENTS FOR WASTEWATER COLLECTION SYSTEMS IN CITIES OF 150,000 TO 500,000 IN POPULATION, Manpower Development Staff, Office of Water Program Operations, U.S. Environmental Protection Agency.*

out obstructions such as roots, grease, or other deposits. Cleans and repairs catch basins, manholes, culverts and storm drains, using hand tools. Raises manhole walls to prescribed street level using hand tools. Measures distance of excavation site using tape measure, and marks outline of area to be trenched according to direction of FOREMAN. Breaks asphalt and other pavement, using air hammer, pick and shovel. Cuts damaged section of pipe with cutters and removes broken section from ditch. Replaces broken pipes and reconnects pipe sections using pipe sleeve. Inspects joints to ensure they are tight and sealed properly before backfilling. Packs backfilled excavation using air and gasoline tamper. Taps main line sewers to install sewer saddles. Replaces manhole covers. Updates sewer maps and manhole charting. Drives pickup truck to haul crew, materials and equipment. Services, adjusts and makes minor repairs to equipment, machines and attachments. Communicates with DISPATCHER, FOREMAN, MAINTENANCE SUPERVISOR, and others, using radio telephone. Gives directions to MAINTENANCE PERSON I, and LABORERS, instructs them in efficient and safe use of machines, trains them in work methods, and ensures that proper procedures and safety precautions are followed. Prepares records showing actions taken, staff time and equipment utilization, and disposition of material. Requisitions tools and equipment. May operate sewer cleaning equipment including power rodder, high velocity water jet, sewer flusher, bucket machine, wayne ball, and vac-all. May clean and disinfect domestic basements and other areas flooded as a result of sewer stoppages. May act as lead person in a large repair and construction crew under the supervision of a FOREMAN.

QUALIFICATION PROFILE

1. Formal Education:

   Usually required to have completed eighth grade. Completion of tenth grade or graduation from high school or vocational school is highly desirable and is increasingly required.

2. General Requirements:

   a. Knowledge of methods, tools, equipment and materials used in sewer construction, repair and maintenance.

   b. Knowledge of layout of city streets and location of sewer lines and related structures.

   c. Knowledge of work hazards and applicable safety precautions.

   d. Ability to locate, detect, and correct sewer stoppages and leaks.

   e. Ability to establish and maintain effective working relations with employees and the general public.

   f. Possession of a valid driver's license.

3. General Educational Development:

   a. Reasoning:

      (1) Apply common sense understanding to carry out instructions furnished in oral, written or diagrammatical form.

      (2) Deal with problems involving several concrete variables in or from standardized situations.

   b. Mathematical:

      Make arithmetic calculations involving fractions, decimals and percentages.

   c. Language:

      (1) Communicate with fellow employees and train subordinates in work methods.

      (2) Fill in maintenance report forms.

4. Specific Vocational Preparation:

   Three years' experience in the repair and maintenance of collection systems is commonly required.

5. Aptitudes - Relative to General Working Population:

a.	Intelligence:	Middle third
b.	Verbal:	Middle third
c.	Numerical:	Middle third
d.	Spatial:	Highest third excluding top 10%
e.	Form Perception:	Middle third
f.	Clerical Perceptions:	Lowest third excluding bottom 10%
g.	Motor Coordination:	Middle third
h.	Finger Dexterity:	Middle third
i.	Manual Dexterity:	Middle third
j.	Eye-Hand-Foot Coordination:	Lowest third excluding bottom 10%
k.	Color Discrimination:	Lowest third excluding bottom 10%

6. Interests:

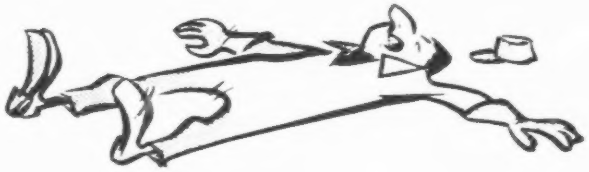
   An interest in activities concerned with things, objects, machines and techniques.

7. Temperament:

   Must adjust to a variety of tasks requiring frequent change and adhere closely to established standards and procedures. Must adjust to making judgmental decisions.

8. Physical Demands:

   Medium to heavy work involving lifting, climbing, stooping, kneeling, crouching, crawling, reaching, handling, fingering, talking, hearing and seeing.



9. Working Conditions:

   The work is outside and involves wet conditions, noise, risks of bodily injury, and exposure to weather, noxious smells, and gases.

ENTRY SOURCES: Mason II, Maintenance Person I, or general public.

PROGRESSION TO: Foreman, Maintenance Supervisor I, or Construction Inspector

12.322 Applications

A superintendent should assist the personnel department in preparing notices of opportunities for employment within the agency's collection system maintenance department, and their distribution to sources of qualified applicants. The notice should give a brief description of the work to be performed, required qualifications, compensation, the selection process, where application forms can be obtained and the closing date for accepting applications. Each agency will have its own standard application form for employment. Application forms and subsequent pre-employment inquiries must respect the civil rights of the applicants. Table 12.3 contains a list of acceptable and unacceptable pre-employment questions that you may use as a guide.

TABLE 12.3 ACCEPTABLE AND UNACCEPTABLE PRE-EMPLOYMENT INQUIRIES[a]

ACCEPTABLE PRE-EMPLOYMENT INQUIRIES	SUBJECT	UNACCEPTABLE PRE-EMPLOYMENT INQUIRIES
"Have you ever worked for this agency under a different name?"	NAME	Former name of applicant whose name has been changed by court order or otherwise.
Applicant's place of residence.	ADDRESS OR DURATION OF RESIDENCE	
How long applicant has been resident of this State or city.		
"Can you, after employment submit a birth certificate or other proof of U.S. citizenship or age?"	BIRTHPLACE	Birthplace of applicant. Birthplace of applicant's parents, spouse or other relatives. Requirement that applicant submit a birth certificate, naturalization or baptismal record.
"If hired, can you furnish proof of age?" /or/ Statement that hire is subject to verification that applicant's age meets legal requirements.	AGE	Questions which tend to identify applicants 40 to 64 years of age.
Statement by employer of regular days, hours or shift to be worked.	RELIGIOUS	Applicant's religious denomination or affiliation, church, parish, pastor, or religious holidays observed. "Do you attend religious services /or/ a house of worship?" Applicant may not be told, "This is a Catholic/Protestant/Jewish/atheist organization."
	RACE OR COLOR	Complexion, color of skin, or other questions directly or indirectly indicating race or color.
Statement that photograph may be required after employment.	PHOTOGRAPH	Requirement that applicant affix a photograph to his/her application form. Request applicant, at his/her option, to submit photograph. Requirement of photograph after interview but before hiring.
Statement by employer that if hired applicant may be required to submit proof of eligibility to work in the United States.	CITIZENSHIP	"Are you a United States citizen?" Whether applicant or applicant's parents or spouse are naturalized or native-born U.S. citizens. Date when applicant or parents or spouse acquired U.S. Citizenship. Requirement that applicant produce naturalization papers or first papers. Whether applicant's parents or spouse are citizens of the U.S.

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[a] *Courtesy of Marion B. McCamey, Affirmative Action Officer, California State University, Sacramento, California.*

TABLE 12.3 ACCEPTABLE AND UNACCEPTABLE PRE-EMPLOYMENT INQUIRIES (Cont'd)

ACCEPTABLE PRE-EMPLOYMENT INQUIRIES	SUBJECT	UNACCEPTABLE PRE-EMPLOYMENT INQUIRIES
Language applicant reads, speaks, or writes fluently.	NATIONAL ORIGIN OR ANCESTRY	Applicant's nationality, lineage, ancestry, national origin, descent or parentage. Date of arrival in United States or port of entry; how long a resident. Nationality of applicant's parents or spouse; maiden name of applicant's wife or mother. Language commonly used by applicant. "What is your mother tongue?" How applicant acquired to read, write or speak a foreign language.
Applicant's academic, vocational, or professional education; schools attended.	EDUCATION	Date last attended high school.
Applicant's work experience Applicant's military experience in armed forces of United States, in a State militia (U.S.), or in a particular branch of the U.S. armed forces.	EXPERIENCE	Applicant's military experience (general). Type of military discharge.
	CHARACTER	"Have you ever been arrested?"
Names of applicant's relatives already employed by the agency.	RELATIVES	Marital status or number of dependents. Name or address of relative, spouse or children of adult applicant. "With whom do you reside?" "Do you live with your parents?"
Organizations, clubs, professional societies, or other associations of which applicant is a member, excluding any names the character of which indicate the race, religious creed, color, national origin, or ancestry of its members.	ORGANIZATIONS	"List all organizations, clubs, societies, and lodges to which you belong."
"By whom were you referred for a position here?"	REFERENCES	Requirement of submission of a religious reference.
"Do you have any physical condition which may limit your ability to perform the job applied for?" Statement by employer that offer may be made contingent on passing a physical examination.	PHYSICAL	"Do you have any physical disabilities?" Questions on general medical condition. Inquiries as to receipt of Workers' Compensation.
Notice to applicant that any misstatements or omissions of material facts in his/her application may be cause for dismissal.	MISCELLANEOUS	Any inquiry that is not job-related or necessary for determining an applicant's eligibility for employment.

DO YOU HAVE ... CONDITION
WHICH MAK... BILITY TO
PERFOR... JOB ... IS.....

12.323 Selection

The next step in the selection process is known as paper screening. The personnel department and the superintendent review each applicant's resume or application form and eliminate those who are obviously not qualified. The remaining applicants are generally given written and other appropriate examinations to verify their qualifications for the position. Then the superintendent interviews the three (or more) most highly qualified applicants and selects the most qualified person.

If you are the superintendent conducting the interview, be aware that the purpose is to gain additional information about the applicants so that the best qualified person can be selected for employment. Prepare for the interview in advance. Review the background information of each applicant. Plan the interview by preparing a list of questions to ask each applicant. When collecting background information and preparing the questions, you must be sensitive to the civil rights of the applicants and the affirmative action policies of your agency. Refer again to the acceptable and unacceptable pre-employment questions outlined in Table 12.3.

Try to conduct the interview in a quiet place where there will be a minimum of distractions such as phones ringing, noisy typewriters and other persons talking or overhearing the interview. Start the interview by placing the applicant at ease. A discussion of something which does not refer to an applicant's ability or eligibility for the job will be relaxing. Opening topics could include results of ball games, weather, traffic or parking problems.

Explain to the applicant the details of the job, working conditions, wages, vacations, potential for advancement, and other important factors. Hopefully by now the applicant has relaxed. Give the applicant a chance to ask questions about the job.

Now you are ready to start asking questions about this person's ability to do the job. These questions should pertain to the work situation and should be phrased so that they ask for specific information rather than "yes" or "no" answers. Jot down a few notes to remind you of each person's responses and general manner. Try to determine why the applicant applied for the job and why he or she feels qualified for this position.

When the interview is over, tell each applicant they will be notified of your decision after the others are interviewed and within a specified number of days. Be honest with the applicant. Employment interviews are an opportunity to build good public relations for your agency today and in the future. If an applicant is not qualified for the job now available but appears qualified for another job, encourage the applicant to investigate the other job.

When all the interviews are over, review your notes. Evaluation of applicants is often difficult. Most people are favorably impressed by the "good talker." A look at your existing personnel can remind you that the best talker may not be the most productive worker. Also beware of the overqualified applicant. Naturally you want the best applicant, but a person who is overqualified may become disappointed with the job and hurt the morale of other personnel.

Before making a final selection, check the references of the person you have tentatively selected. Try to speak directly with the applicant's previous supervisors rather than with a personnel officer. If the applicant is presently employed, they may request that you not contact their employer until a firm offer of employment is made. In such a case you could attempt to speak with previous employers or ask the applicant for additional references who could provide information about the applicant's professional skills.

The main purpose of checking references is to verify an applicant's previous experience. In some cases, that is the only information an employer will give you. In other cases, you may be able to learn a great deal about the applicant's skills and abilities. Some of the questions you might ask are: Was the employee reliable or punctual? How well did the applicant relate to co-workers? How well did he communicate with supervisors? Did the applicant consistently practice safe work procedures? Would you rehire this person?

The final step in the selection process is to require the best qualified applicant to pass a medical examination to determine the person's physical ability to perform the designated work.

Once your offer of employment has been accepted, promptly notify all other applicants that the position has been filled and thank them for their interest in your organization.

12.324 Employee Orientation

During the first day of work, a new employee should be given all the information available in written and verbal form on the agency's policies and practices concerning compensation, benefits, attendance and other matters relating to employer-employee relations. Any questions that a new employee has concerning agency and department operating policies and practices should be answered at this time.

Conclude the orientation with introduction of the new employee to co-workers and the work area. Remember the new employee's first impression of the agency and its personnel is very important.

12.325 Probationary Period

Many businesses find the use of probationary periods extremely helpful in selecting new employees. This is usually a period of 90 to 120 days beginning when a new employee is hired. Management may reserve the right to terminate employment of the person with or without cause during this period, provided the employee is properly advised in advance that he or she must successfully complete the probationary period to move to regular employee status.

The probationary period provides a time during which both the agency and the employee can assess the "fit" between the job and the person. A satisfactory performance evaluation near the end of the probationary period is often the mechanism by which a new employee officially achieves regular employee status.

Check with your personnel office and/or legal department for information about probationary periods since they may well be covered by a union contract or collective bargaining agreement.

12.33 Compensation

The compensation an employee receives for the work performed includes satisfaction, recognition, security, appropriate pay and benefits. All are important for the retention of good employees. However, appropriate pay for the work performed is the cornerstone of any compensation package.

12.331 Salaries

Most employees of a wastewater collection agency will work full time and be paid a monthly salary with an hourly rate component for calculating any overtime work compensation and job costs. The salary an employee receives may be determined unilaterally by the agency or by negotiation with formal or informal organizations representing employee groups. In either situation, salaries must comply with minimums established by state and federal regulations and are generally based on the standards established by other employers within a recognized area of influence. Salary standards can be determined by surveying other agencies with similar positions and must take into account the similarities (or the lack of similarities) of the positions being compared. The results of the survey are then used as a basis for determining the appropriate salary for an agency's unique conditions.

12.332 Benefits

Benefits paid for by the employer are also an important part of the total compensation an employee receives for work performed and generally include the following:

1. Social security (employer's contribution),
2. Retirement,
3. Hospitalization or health insurance,
4. Life insurance,
5. Holiday pay,
6. Vacation pay,
7. Sick leave,
8. Personal leave,
9. Worker's compensation, and
10. Protective clothing.

In addition, the following more specific benefits are sometimes given to employees:

1. Cash bonus,
2. Longevity pay,
3. Dental and/or vision insurance,
4. Long-term disability insurance,
5. Educational bonus,
6. Educational cost and leave,
7. Bereavement leave,
8. Parental leave, and
9. Release time for jury duty.

The cost of the benefits is usually paid by the employer, although in some instances costs are shared with employees. It is not uncommon for benefits to cost an employer between 30 and 50 percent of an employee's salary. Employers often compute the cost of benefits and print an itemized list on employees' monthly pay stubs. This practice reminds employees to consider their total compensation package rather than focus on an hourly or monthly salary amount.

The benefits provided by an agency may not be the same or equal in value for all groups of employees. For example, management employees might be eligible to participate in "enhanced" or broadened medical insurance programs as part of their total compensation package. Also, union contracts sometimes specify varying benefit packages for different groups of employees.

12.333 Adjustments

Adjustments to the starting salary for an employee remaining in the same position are generally based on the following factors:

- Longevity and a concurrent improvement in performance, and
- Increases in the cost of living.

Longevity pay increases are generally given after the first six months of satisfactory employment followed by annual increases thereafter. A five-step merit salary increase schedule is commonly used by agencies. Such salary increases should not be given automatically. They should be given only after a thorough evaluation of an employee's performance by a supervisor demonstrates that a merit increase has been earned.

Cost of living increases are usually given annually and based on the Wage Earner and Clerical Worker Consumer Price Index increase for the latest preceding twelve-month period published by the Bureau of Labor Statistics, U.S. Government. Cost of living increases are either given unilaterally by an agency or are negotiated with employee representatives.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 396

12.3D Why is making the proper selection of personnel important?

12.3E What are the potential positions of advancement for a Maintenance Person II, Wastewater Collection?

12.3F What information should be listed on "opportunities for employment" notice?

12.3G What information should be given a new employee during the first day of work?

12.3H What types of adjustments are commonly made to an employee's starting salary?

12.34 Training, Informing and Certification

A prime responsibility of every supervisor is to assure the proper training of assigned personnel so that they may perform their work in a safe and efficient manner. Appropriate certification of competency, when available from an authoritative group or agency, should at least be encouraged by an agency and its supervisors, and may be required for promotions and step salary increases. Personnel also need to be informed about internal and external activities of the agency to make them realize they are an important part of the agency's team.

12.341 Training

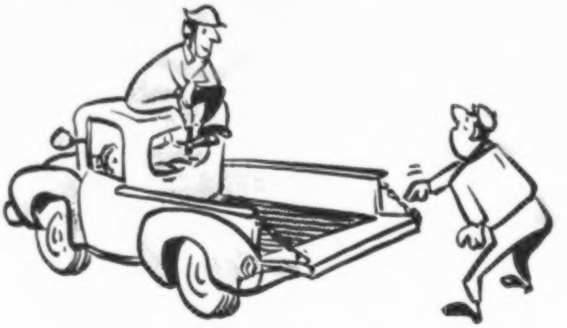
An effective supervisor is constantly looking for opportunities to train assigned personnel to improve performance. The following paragraphs describe some common training techniques.

ON THE JOB

Unfortunately, to this point in time, very little has been offered in the way of formal courses to assist in training collection system operators. Most of the training operators receive is some type of "on-the-job training" conducted by experienced collection system operators when they are available. This type of training is important, of course, and it has been effective to a degree. The fact that collection systems have continued to function and in many areas improved their efficiency through such training efforts is proof of the effectiveness of on-the-job training.

One potential limitation of on-the-job training is that because it relies on "in house" teachers, it could be too narrow in scope. Such training tends to reflect local conditions, philosophies, and experience unless the instructor makes special efforts to broaden the scope.

Effective training techniques include informal meetings using information on available material, suppliers, sharing knowledge of crew personnel, and invited guests to talk over how to do specific jobs. Equipment manufacturers and materials suppliers are often available to train new operators and retrain existing operators on use of equipment.



PROFESSIONAL MAGAZINES AND PAPERS

Articles published in local or national professional magazines are an excellent source of information about new products and procedures and could be used as the basis of a training session. Two good examples of professional magazines are the *OPERATIONS FORUM*, published by the Water Pollution Control Federation, 601 Wythe Street, Alexandria, Virginia 22314-1994, and *APWA REPORTER*, published by the American Public Works Association, 1313 East Sixtieth Street, Chicago, Illinois 60637. Local or regional wastewater associations periodically conduct workshops where experienced collection system operators present papers that are of value in training less experienced people in the field of collection system operation and maintenance. Such workshops make information available to smaller organizations in remote areas who would otherwise not have the benefit of such broad experience.

FORMAL TRAINING

Through the efforts of local and state water pollution control associations, the Water Pollution Control Federation, and the U.S. Environmental Protection Agency, attempts are now being made to make formal training available to all collection system operators. Such training also is being made available to others not now in the collection system field, but who would like to prepare for jobs within the field. This particular training course is a result of such efforts.

The need for effective training programs does not stop with collection system operators. Staff personnel, particularly superintendents and supervisors, need to develop a personal continuing educational program, vigorously supported by the employing agency, so that they will be able to apply the latest efficient techniques to their operations.

12.342 Informing

In addition to providing job-related training, an agency should also inform its operators and staff of the agency's operations. The following are some items of information that will help to build a team spirit among an agency's personnel.

RESULTS ACHIEVED

A good supervisor will know if the maintenance program is producing the desired results. The supervisor will be proud to make management aware of success, but how about the collection system operators? Supervisors should be equally concerned with making them aware of the results achieved.

ANNUAL REPORT

Collection system operators who have spent a year balling, rodding, operating a high velocity cleaner, and TV equipment, have a right to know what their year's efforts have produced. A wise supervisor will make it a practice to hold an annual report meeting with assigned personnel to inform them of their accomplishments. This does not have to be a "pat on the back" meeting. The personnel will appreciate the consideration shown in appraising them of the part their particular function has played in the objectives of the total maintenance program. Without being told specifically, they will not become aware of their importance to the organization. Such awareness may well result in increased effort on their parts to improve their performance from year to year.

AGENCY FINANCING

Distribute copies of your agency's annual budget and financial statement to all personnel and answer all questions, particularly those relating to their work.

AGENCY RECOGNITION

Any recognition that an agency receives for exceptional performance (good or bad) should be passed on to its personnel since they are a part of the team that produced the results being recognized. If the results were good, they will have the satisfaction of doing a good job; and if the results were bad, they will very likely want to help improve the agency's performance.

12.343 Certification

A few states now require certification of competency for wastewater collection system operators in recognition of the importance of good operation and maintenance of the system for the health and safety of the public. Also many state water pollution control associations, in states not requiring certification, have voluntary certification programs. Either a mandatory or voluntary certification program provides recognition of wastewater collection personnel for the technical skills and knowledge they have acquired and applied to their tasks. Certified personnel are sometimes paid a salary higher than uncertified personnel.

Both mandatory and voluntary certification programs for collection systems personnel include written, and sometimes verbal, examinations. Guides for preparing for the examinations, including sample questions, are usually provided by the organization administering the certification program. Preparing for a certification examination is a good approach to continuing an education and training in the techniques, procedures, equipment and materials used for the efficient operation and maintenance of collection systems. Passing an examination shows that a person has learned the covered subjects and can apply the knowledge acquired in a competent manner.

12.35 Employee Relations

Some supervisors are up to their ears in employee relations and unions and others have never met a union representative or a shop steward. By reading this section you may understand why some employees join unions to obtain benefits and how non-union employees obtain the benefits others have gained with the help of a union. Collection system personnel have joined unions in hopes of achieving higher wages, greater benefits, and other economic objectives, as well as improved working conditions.

Whether an agency's employees belong to a union now or may join one in the future, a good employee-management relationship is crucial to keeping an agency functioning properly. Managers, supervisors, crew leaders and operators all have to want to work together to develop a good relationship. The supervisor is the critical link in the relationship and is management's daily representative with the operators.

12.351 Negotiations

During employee negotiations, management should be in constant consultation with the supervisors. Many employee demands regarding working conditions originate from the supervisor's daily dealings with the employees. An effective supervisor can minimize unreasonable demands. Also any demands that are agreed upon must be implemented and carried out by a supervisor. Although a supervisor does not participate directly in labor negotiations, the supervisor can help both sides reach an acceptable contractual agreement.

12.352 Contracts

Once a contract has been agreed upon by a union and employer, the supervisor must manage the organization within the framework of the contract. Do not attempt to ignore or "get around" the contract, even if you disagree with some of the clauses or feel they hinder you from achieving your objectives. If you do not understand certain contract provisions or the spirit of the agreement, ask management to explain this portion of the contract BEFORE you apply these clauses to your daily working situation.

Contracts do not change the supervisor's delegated authority or responsibility. Operators must carry out the supervisor's orders and get the job done properly, safely and within a reasonable amount of time. As a supervisor you must learn to do your job within the framework of the contract.

CONTRACT PROVISION
PORTION OF CONTRACT
RESPONSIBILITY
FRAMEWORK OF
TO MAKE DECISION
YOUR DECISION
SPIRIT OF THE AGREEMENT
PLUS DELEGATED AUTHORITY OR
GET JOB DONE WITHIN THE
CONTRACT - RIGHT OR DUTY
RIGHT TO PROTECT OR CHALLENGE
14 RESPONSIBILITY

As a supervisor you must always realize that as a member of management you have the right and even the duty to make decisions. However, a contract gives a union the right to protest or challenge your decision. When an operator requires discipline, disciplinary action is a management responsibility and a right. The supervisor has a duty to take action whenever employees do not comply with contract provisions.

Most of a supervisor's union contacts are with a shop steward. The shop steward is elected by the union employees and is their official representative to management and the local union. The steward is in a difficult position because the steward is an employee who is expected to do a full-time job like the other employees, yet also represent the employees. The steward must create an effective link between the supervisor and employees.

12.353 Grievances

Handling grievances can be a very time-consuming job for both the supervisor and the steward. Grievances can develop over disciplinary action, distribution of overtime, transfers, promotions, demotions and interpretation of labor contracts. The steward must communicate complaints and grievances from operators to the supervisor. The supervisor and the steward must work together to settle complaints and adjust grievances. Union contracts usually spell out in great detail the steps and procedures the steward and the supervisor must follow to settle differences. When a shop steward and supervisor can work together, the steward can help the supervisor to be an effective manager.

Successful handling of complaints and adjusting grievances requires cooperation by both the stop steward and the supervisor. Both have to use judgement, tact and patience and somehow do their daily work also. The better they can work together, the fewer grievances will develop and become serious, and the less time will be consumed settling such problems.

Assume you are a supervisor and the shop steward presents a grievance to you. During the presentation and discussion (the employee should be present, too), listen carefully and sympathetically to the steward. Discuss the problem with the employee directly or with the help of the shop steward. Try to identify the facts and the cause of the problem and try not to get caught up in irrelevant side issues. Make every effort to settle the grievance quickly and to the satisfaction of everyone involved.

Try to prevent little grievances from becoming big ones and going on to top management by letting the staff and shop steward know you are available and willing to discuss their problems. You and the shop steward and the employee must all listen sympathetically to each other's viewpoints and avoid becoming angry. Seek out complete and accurate facts about the situation, review the labor contract for pertinent clauses, and try to settle the grievance as quickly and justly as possible.

The consequences of any solution to a grievance must be considered and solutions must be consistent and fair to the other operators. The solution or settlement should be clear and understandable to everyone involved. Written records must be maintained and properly filed that document the entire grievance procedure from initial presentation to final solution and settlement. The supervisor and the shop steward should review the final report together to be sure the intent of the solution is understood and properly documented.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 397.

12.3I Why should collection system operators be properly trained?

12.3J How can collection system operators be trained?

12.3K In addition to agency policies and procedures, what other kinds of information should be given to collection system operators?

12.3L What is the purpose of an annual meeting?

12.3M Describe the relationship that should exist between the supervisor and the shop steward.

12.36 Safety

The superintendent of a wastewater collection system department has the responsibility for the safety of the department's personnel and the public exposed to its operations. Therefore, the superintendent must develop and administer an effective safety program. The basic elements of a safety program include a safety policy statement (including disciplinary procedures), safety training and promotion, and accident investigation and reporting.

12.361 Policy Statement

The safety policy statement should be prepared by the top management of the collection system agency since its purpose is to let employees know that the safety program has the full support of the agency and its management. The statement should:

1. Define the goals and objectives of the program,
2. Identify the persons responsible for each element of the program
3. Affirm management's intent to enforce safety regulations, and
4. Describe the disciplinary actions that will be taken to enforce safe work practices.

Give a copy of the safety policy statement to every current employee as well as to each new employee during orientation.

12.362 Responsibilities

The following listing of responsibilities for safety are set forth on pages 104 and 105 of *PLANT MANAGER'S HANDBOOK.*[3]

Management has the responsibility to:

1. Formulate a written safety policy,
2. Provide a safe work place,
3. Set achievable safety goals,
4. Provide adequate training, and
5. Delegate authority to ensure that the program is properly implemented.

The manager is the key to any safety program. Implementation and enforcement of the program is the responsibility of the manager. The manager also has the responsibility to:

1. Ensure that all employees are trained and periodically retrained in proper safe work practices,
2. Ensure that proper safety practices are implemented and continued as long as the policy is in effect,
3. Investigate all accidents and injuries to determine their cause,
4. Institute corrective measures where unsafe conditions or work methods exist, and
5. Ensure that equipment, tools, and the work area are maintained to comply with established safety standards.

The collection system operators are the direct beneficiaries of a safety program. The operators share the responsibility to:

1. Observe prescribed work procedures with respect to personal safety and that of their co-workers,
2. Report any detected hazard to a manager immediately,
3. Report any minor accident that causes minor injuries,
4. Report near-miss accidents so that hazards can be removed or procedures changed to avoid problems in the future, and
5. Use all protective devices and safety equipment supplied to reduce the possibility of injury.

12.363 Training and Promotion

The superintendent must establish an ongoing safety training program for assigned personnel. There should be an established schedule of safety training sessions including weekly tailgate training sessions for operating crews. Use the sessions to introduce new safety procedures, discuss recent accidents, hear employee suggestions and reinforce existing procedures. Invite outside speakers to discuss safety topics. You will find sources of safety training material in Chapter 11 of this manual, your agency's insurance company, the Water Pollution Control Federation and its member associations, the National Safety Council and the National Institute of Occupational Safety and Health.

Management should promote safety by personal example and the establishment of an award program for safe work practices.

12.364 Accident Investigations

Investigate every accident, no matter how minor, and make a written report on the findings. The primary purpose of the investigation is to determine the cause and how best to avoid a similar and possibly more serious accident from occurring in the future. Discuss the accident immediately with the personnel involved and take disciplinary action if safety regulations were violated. Also, use the accident report as the basis for discussion at the next general personnel safety meeting. A complete accident report will be very valuable if there is a subsequent claim of injury or property damage.

Your agency may have accident report forms or they may be obtained from your agency's insurance company.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 397.

12.3N What are the basic elements of a superintendent's safety program?

12.3O Who should prepare a safety policy statement?

12.3P What are management's responsibilities with regard to safety?

12.3Q What are the collection system operators' responsibilities with regard to safety?

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[3] *PLANT MANAGER'S HANDBOOK. Available from Water Pollution Control Federation, 601 Wythe Street, Alexandria, Virginia 22314-1994. Order number MSM40H0. Price to members, $28.00; others, $34.00*

DISCUSSION AND REVIEW QUESTIONS

Chapter 12. ADMINISTRATION

(Lesson 2 of 7 Lessons)

Please write your answers in a notebook before continuing. The question numbering continues from Lesson 1.

6. How do factors such as total length of sewers serviced, population, industry, type of problems, and topography influence the organization that operates and maintains the collection system?
7. What general procedures would you follow to hire a new collection system operator?
8. What is the purpose of interviewing an applicant for a job?
9. What are the different types of compensation that an employee receives from a job?
10. What types of job training are available to operators?
11. What is the job of the supervisor in labor relations?
12. What should be contained or defined in a safety policy statement?

CHAPTER 12. ADMINISTRATION

(Lesson 3 of 7 Lessons)

12.4 EQUIPMENT AND TOOLS

Many of the tools and equipment we will be discussing have been thoroughly described in other chapters of this manual. Detailed instructions have been given as to how each can and should be used. The advantages and limitations of each, relative to their abilities to cope with specific problems, have been explained. In this chapter our comments will be limited to points of interest to supervisors.

12.41 Basis for Requirements

As with staffing, tool and equipment requirements will depend largely on such things as size of the collection system, work load, and objectives. Other important factors include age and condition of the system as well as the types and number of problem areas.

12.411 Equipment Tailored to Program

The equipment of a wastewater collection system department should be tailored to the superintendent's program for operation and maintenance of the system. As obvious as this may seem, the opposite is quite often the situation. Sometimes programs are designed to fit the equipment available. In many cases this does not come about by choice, it merely develops from circumstances. What circumstances? How does this situation develop? Quite simply. Prior supervisors or management acquire the tools and equipment needed to carry out their desired programs and new supervisors conform their programs to the available equipment. Then, as time passes, subsequent supervisors may find this available equipment no longer suits their current plans or programs. This can be due to a variety of reasons, such as:

1. Changing conditions within the collection system,
2. Development of more modern and specialized equipment, or
3. More intelligent approach and appraisal of existing problems and needs by current supervisors and planning for a more effective program.

How this situation came about is really not important. The important point is to be able to recognize this situation when it does occur. Then it will take knowledge and courage to document and justify your request for the appropriate tools and equipment which you will need to implement your programs and meet your objectives.

MULTI-PURPOSE EQUIPMENT

One of the questions supervisors ask most frequently and one that is most difficult to answer is what kind, type, and size of equipment should be purchased? Smaller organizations who cannot afford or whose needs don't justify the purchase of various specialized equipment find this problem especially difficult. With $10,000 or $20,000 in available funds, what one piece of equipment will be the most versatile and efficient in coping with the variety of problems faced in the collection system? We will not attempt to answer that question. Instead, we offer this analogy:

You are a homesteader with a small plot of land. To make the land productive you will have to hoe some weeds and dig some shallow, narrow ditches. What you need is a hoe and a shovel, but you can only afford one tool. The hoe would be best for cutting the weeds, a shovel the best for digging the ditches. If necessary, you could cut the weeds with the shovel, or dig the shallow ditches with a hoe. Which tool do you buy? If weeds are the predominant problem, you would buy the hoe. If ditches are the major work load, the shovel. The homesteader will assess his particular needs and make the choice accordingly.

As maintenance supervisor, you could be facing a decision very similar to the homesteader's choice. However, your decision will be more complex. We have learned in this course that certain equipment will do an excellent job of removing roots, another will be most efficient in removing grease accumulation, and still another most effective in removing grit and solid material that has settled out within the collection system. Some equipment has been suggested as efficient, to a degree, in dealing with all these problems (see Chapter 6, Section 6.14, "Selection of Solution to Problem," Tables 6.1 and 6.2).

As a supervisor, you should have the knowledge and the experience to identify your predominant maintenance problem and select the equipment that would do the best overall job in your collection system.

SPECIALIZED EQUIPMENT

Much of the equipment which is available today for collection system maintenance is specialized. Many manufacturers claim that their equipment is capable of dealing with a variety of maintenance problems, and, to a degree, they are correct. It also is true, however, that most modern collection system maintenance equipment has one particular function that it performs most effectively. Ask the manufacturer's representative to demonstrate the equipment you are interested in on an actual condition that exists in the collection system or in the above-ground training facility, if available, so you can see the equipment in action. Also ask the representative to give you the names of other nearby superintendents who are using the same equipment.

In making the decision to buy specialized equipment, proceed with much caution, consideration, and thorough analysis of your collection system. Do you have a specific problem prevalent within your system and of sufficient proportions to justify purchasing of such specialized equipment? In many maintenance yards throughout this country you will find specialized equipment parked and standing idle much of the time because the need for it and/or its efficiency was overrated.

12.412 Efficient Use

Modern maintenance equipment is expensive. The operators who use it are expensive too and in most cases will need some additional specialized training. The supervisor should be constantly concerned that the equipment is being operated efficiently. As previously stated, most equipment has one function which it does best. Be certain that the equipment is being used in those areas where it is most needed. The shotgun approach of "going through a system at set intervals with one piece of equipment" is wasteful and unnecessary. Unfortunately it is a common practice.

12.42 Lease, Purchase, or Contract

It is not always necessary to purchase the equipment you need to implement your maintenance programs. There are several alternatives to committing your funds this way. All types of construction and maintenance equipment are available through long- or short-term leasing, as well as by outright purchase. Leasing makes available, to the smaller agencies in particular, many useful items of equipment which they could not justify purchasing for part-time use. Larger organizations also find an attractive alternative to outright purchase of expensive equipment which requires a significant initial investment.

12.421 Advantages of Leasing

There are advantages to be realized through leasing for both large and small collection agencies.

LARGE ORGANIZATIONS

Naturally the first benefit to be realized is that expensive equipment can be available without a large initial capital expenditure, but there are other important benefits to be considered. Many large organizations have purchased expensive equipment such as closed-circuit television or high velocity cleaners and discovered a short time later, much to their disappointment, that similar but better equipment became available. Because of the large investment, they have little choice but to keep and use their original equipment over a period of years necessary to amortize their original investment.

Another advantage is that most leasing agreements can be negotiated on a one- to three-year basis for this type of equipment. This assures you that you will not be faced with operating equipment that has become obsolete in some respects. When new developments and improvements become available, they can be easily acquired through new leasing agreements.

SMALL AGENCIES

Small agencies probably realize the greatest benefits form equipment leasing. Often their anticipated need or work load would not even allow consideration of purchasing needed equipment outright. Before leasing arrangements were widely available, a small agency's only alternative was to employ outside contractors who provided both the staff and the equipment needed to do the job. Such contracts often were expensive. With leasing, however, all types of equipment may be within their financial capabilities for short time periods to do specific jobs. Many leasing agencies will provide a break-in time and training period to train your own operators as part of the leasing agreement. This is usually a less expensive method than contracting for both staff and equipment. If a need can be demonstrated, leasing for a limited time period should be an easier approach to sell top management than buying equipment for part-time use.

COMMON ADVANTAGES

Leasing offers advantages common to any size agency. It makes any specialized equipment available at reasonable cost to complete any one-time or seasonal programs you may want to undertake. Some leasing agreements allow you to apply all or part of the leasing costs towards purchase of the equipment if you decide that the equipment leased best suits your present and future needs. The technical assistance offices of some state municipal leagues have conducted studies on the costs and benefits of leasing and purchasing. You may want to consult with them if you are considering leasing some equipment.

Often leased equipment can be obtained more quickly than purchased equipment. When leased equipment breaks down, usually it is quickly replaced because the agency doesn't have to pay for equipment that doesn't work.

LIMITATION

The total costs of leasing may be more in the long run than the cost of purchasing equipment. Keep in mind, however, that leasing costs are spread out over the years while the equipment is being used.

12.422 Advantages of Purchasing

Regardless of its size, there are advantages to any organization in outright purchase of some types of equipment. In general, purchases should be limited to the more standard equipment that is used frequently, has a long life span, and represents capital investment within the scope of the available budget. The need to purchase new or replacement equipment should be anticipated and a replacement fund established for such purchase in order to spread the total cost over several years.

LIMITATIONS

a. Large initial capital investment,

b. Equipment must be kept and used five to eight years in order to build up a replacement fund,

c. It is difficult to obtain newer models that are capable of doing a better job until old equipment wears out, and

d. Equipment may require specially trained mechanics to provide proper maintenance.

12.423 Advantages of Contracting

Sometimes your agency may not have sufficient qualified or qualifiable operators available to do a highly specialized job. Under these conditions, a contract with a firm specializing in solving a particular problem may be the best approach.

LIMITATION

This may be most expensive method, but could be satisfactory for a small job that can be done in a short time.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 397

12.4A How can tool and equipment requirements be determined?

12.4B Is most of the equipment available for collection system maintenance specialized or is it capable of dealing with a variety of problems?

12.4C Why is the shotgun approach of "going through a system at set intervals with one piece of equipment" not recommended?

12.4D How can an agency implement a preventive maintenance program when it does not have enough money to purchase the necessary equipment?

12.4E What are some advantages of leasing equipment?

12.4F What are some advantages of purchasing equipment?

12.4G What are some advantages of contracting for work?

12.43 Equipment and Tool Requirements

The new superintendent of the Clearwater wastewater collection system described in Section 12.31 is now ready to prepare a list of the equipment and tools for the division's new operation and maintenance program, as outlined in Table 12.1.

12.431 Vehicles

Vehicles are required to carry personnel, equipment, tools and materials to and from operation and maintenance sites.

SUPERVISORS

In most areas, supervisors will find a sedan is the most practical and economical type of transportation. Some levels of supervision, such as foremen, may be better served by a pickup truck. This type of truck provides space for carrying safety equipment (such as barricades) and also provides space for foremen to carry supplies to crews in the field. In both cases, two-way radio equipment or paging devices will add to the efficiency of the operation.

EMERGENCY TRUCK

Provide at least a ¾-ton truck for emergency crews who clear stoppages. The size of the truck could be larger if this crew is to serve as a repair crew when not on emergency calls. If two-way radios are limited in number, the emergency crew should receive high priority for obvious reasons. An enclosed, utility-type body also is desirable. An adequate, clean, dry storage area for all necessary maps of the system is a must for this vehicle.

BALLING TRUCKS

A one-ton flatbed truck equipped with tool boxes is commonly used. This truck should carry a hand-operated portable reel with a light cable for balling smaller lines in rear easements. It should also be equipped with a power winch, powered by an auxiliary engine or by a power take off (PTO) from the truck's engine, for balling larger lines in streets. A one-ton trailer for hauling grit removed from the system should accompany each truck.

A water truck holding 1,000 to 2,000 gallons of water should be provided if fire hydrants and hoses are not used for augmenting the flow of water in sewer lines during a balling operation. Sometimes a water truck is outfitted with the equipment listed above and a 3/4-ton pickup truck is used instead of the flat-bed truck and trailer to haul tools and the grit removed by the cleaning operation.

Two-way radio equipment or paging devices may not be required for such vehicles because their daily assignment will usually be confined to a reasonably small area and they can easily be contacted if necessary.

RODDING TRUCKS (Other than truck-mounted power rodders)

If your rod crews' equipment consists of hand rodding gear, or trailer-mounted power rodding machines, a 3/4 or 1-ton truck should be adequate. A utility-type body is desirable. Depending on the number of such crews available, it may be wise to equip at least one with a two-way radio or paging device to make it available for emergencies. The truck should also be equipped with an electric hoist for loading and unloading an electric-powered building sewer rodder, and with an electric generator for the rodder.

BUCKETING AND FLUSHING TRUCKS

Since bucketing machines are trailer-mounted and their use is infrequent, trucks used in other maintenance operations can be used to tow the trailers to and from the job site. Also, the water truck used for balling sewer lines can be used to flush the few small-diameter sewer lines scheduled for this cleaning method.

MAIN LINE REPAIR TRUCK

The basic truck for most main line repair crews should be at least a 1 1/2-ton flatbed with a load capacity sufficient to carry the heavy materials these crews ordinarily use. Such materials might consist of collection system pipe and fittings, manhole grade rings, manhole barrel sections, small amounts of paving material, aggregate and cement, base rock, and sand. A bigger truck may be required for larger jobs. These crews usually work in the same location all day so two-way radio equipment or a paging device is not essential.

SERVICE LINE AND MANHOLE REPAIR TRUCK

A 1-ton truck should be adequate in most areas. Size could depend on the particular tasks these trucks are assigned to. If you have only one repair crew to handle any size repair project, you may want to obtain a larger truck like the one described above for main line repair crews. Also, depending on the number of such trucks available, you may want to equip one truck with a two-way radio or a paging device for emergency use when needed.

LIFT STATIONS TRUCK

A 3/4-ton truck with a utility body should be provided for the lift station crew for inspections, maintenance and minor repairs. The main repair truck can also be used for major lift station repairs. The truck should be equipped with an electric hoist for removing pumps and heavy fittings from lift stations.

INSPECTION AND CONTROL TRUCK

A 1/2-ton pickup truck equipped with a utility box can be used for main, TV and industrial inspections, and infiltration and inflow investigations. Also, one of the trucks assigned to other crews can be used for the chemical treatment of sewer lines.

GENERAL

All vehicles should be equipped with a fire extinguisher, a first aid kit of adequate size, and vehicle and personal accident forms. All operators must have their personal safety equipment with them at all times.

12.432 Special Equipment

In addition to the vehicles listed above, the special equipment described in the following paragraphs will be needed for the operation and maintenance of the Clearwater collection system.

HIGH VELOCITY CLEANERS

This equipment is available in both truck-mounted and trailer units; truck-mounted units are most commonly used. Special care should be exercised in the selection of the truck to carry this unit. Because of the considerable weight of the water carried in high velocity cleaner tanks, it is a common mistake to specify a truck that is of inadequate capacity, or marginal capacity, for the loads involved. Frequently, the insufficient capacity will not become apparent until the truck has been in use for a period of time. With use, brake problems may develop, springs weaken, road handling become less efficient, and even a loss of engine power could become evident. Unfortunately, by the time these conditions materialize, it is often too late to remedy; the truck is yours and guarantees have expired. Again, specify a truck that is oversized, never one that is marginal in capacity.

A high velocity cleaner can be equipped with an engine-driven vacuum pump and piping to suck the debris from the cleaning operation from the downstream manhole if this method of removal is preferred to entry into a manhole and removal with hand tools. Or, the vacuum pump and engine can be trailer-mounted for independent operation.

BUCKET MACHINES

These units are trailer-mounted and are used in pairs; they are equipped to be towed in tandem by one vehicle. Vehicles of at least 3/4-ton capacity should be used when towing two such units. You may also need a dump truck if large lines are being cleaned and large amounts of material are being removed. Attachments to the bucket machines are available which will allow for direct deposit of the material being removed into the trucks. This eliminates the work of dumping the material onto street surfaces and subsequently loading it into trucks by hand shoveling.

RODDING MACHINES

This equipment also is available in truck-mounted or trailer-mounted units. For full-time use, the truck-mounted unit is preferable. Trailer units are advantageous when they are to be used less than full time. These units can be towed by a 3/4-ton truck or larger, depending upon the size of the rodding machine unit.

Building sewers are maintained to five feet past the property line by the City of Clearwater. An electrical power rodder with a flexible spring cable and tools capable of negotiating the bends and cleanout of a four inch-diameter building sewer will be required. A gasoline engine-driven electric generator or one run by a truck engine will be needed to power the rodder.

BACKHOE AND LOADER

Organizations that undertake construction or repair projects of a significant size will need a backhoe and loader. Depending on the anticipated use, a backhoe and loader can be purchased, leased, rented by the day, or hired complete with operator. Sanitary collection systems are now commonly being installed at greater depths which makes this equipment more desirable. Often, a backhoe and loader will provide the ability to complete an excavation, repair, and backfilling in one day. To provide mobility, a trailer of adequate size and meeting local highway regulations will be required to transport backhoe and loader from job to job.

DUMP TRUCKS

A truck with a five-yard load capacity should be adequate. This truck is used as the towing vehicle for the backhoe trailer. It can also be used to haul away excavated material when such material is unsuitable for backfill and to haul in selected backfill when required.

WATER TRUCK

A water truck is another piece of equipment which will be required to work in conjunction with construction crews. It can be used for dust control on the job site, jetting, and cleanup. These trucks come in a variety of sizes and water tank capacities; minimum size should be at least 1,000-gallon capacity. If a water truck is used for balling sewer lines, the same truck can be used for construction and repairs.

AIR COMPRESSORS, PORTABLE

A portable air compressor is required by repair and construction crews for operation of jack hammers and tampers. Compressors are also used for the operation of a sheeting driver head. Some organizations with many crews will install compressors permanently on their repair trucks. To others, where use is not so great, portable, trailer-mounted units may be more practical. Portable, trailer-mounted units can be made available to a greater number of crews on a simple need basis and provide more flexibility of operation.

HOISTS

Truck-mounted hoists, operated on 12-volt systems, are useful on repair and construction vehicles. They should be of sufficient lifting capacity to lift such items as manhole frames and covers, large size pipes, manhole grade rings, and light portable equipment.

PUMPS, TRAILER-MOUNTED

Some equipment of this type will be advantageous to most maintenance organizations. The minimum recommended size is a 4-inch diameter pump discharge although 6, 8, 10-inch or larger discharges could be used by bigger organizations.

These units are usually trailer-mounted with their own pump power source and are portable. Trailers should be equipped to carry all the necessary suction and discharge hoses or pipes that will be needed to set up pumps quickly in emergency situations. Such standby pumping units should be checked and run at regular intervals to assure that they will be in operating condition when the emergency does arise.

CLOSED-CIRCUIT TELEVISION

A variety of units are available. Self-contained vans, larger trailer units, and small, compact trailer units are available. It is impractical to suggest a particular type of unit best suited for any organization. All have advantages. The smaller units, naturally, are practical where their use may limited. All trailer units have the advantage of making the towing vehicle available for other uses when the television trailer is not in use. Truck-mounted units provide easier handling and operation in congested traffic areas.

CHEMICAL APPLICATOR

A manufactured, trailer-mounted unit for the storage, foaming and injection of root control chemicals into main and building sewer lines may be used when the flooding method cannot be used.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 398

12.4H Emergency crews should be provided with what kind of transportation?

12.4I Which crews should be equipped with two-way radios or paging devices?

12.4J Why is it important to specify a truck with adequate capacity for a high velocity cleaner?

12.4K When are truck-mounted equipment units preferable over trailer-mounted units?

12.4L Why should portable standby pumping units be inspected and run at regular intervals?

12.4M What major pieces of equipment are needed for construction and repairs?

12.4N Why do construction and repair crews need a portable air compressor?

12.433 Miscellaneous Equipment and Tools

The following is a listing of some of the more common miscellaneous equipment and tools that will be needed for the maintenance and operation of the Clearwater collection system. These and additional items will be purchased or rented as their need arises.

SEALING AND TESTING

Equipment for air testing collection system joints for leaks and for sealing such leaks is widely used today. This equipment is commonly used in conjunction with closed-circuit television equipment, and may be purchased separately or in conjunction with TV units. A complete unit that provides for television inspection, air testing, and joint sealing equipment can be purchased as a package mounted on a truck or trailer unit.

SEWER BALLS

Balls for cleaning collection system pipes are available in sizes from 6 inches to 48 inches in diameter. Larger sizes are available by special order. Most maintenance organizations will equip individual balling trucks with 12 inch or smaller sizes. Sizes above 12 inches become very expensive and are less frequently used. Depending on the size of the collection system, it is more practical to acquire only one each of the large size balls. These are kept in a central store or tool room and are available to whichever crew may have use for them.

PUMPS, PORTABLE

Portable, gasoline-powered pumps, with 1 1/2 to 2 1/2-inch discharge capacity are often required by repair and maintenance crews. These pumps are stored in a tool room and issued to crews whenever needed.

GENERATORS, PORTABLE

Gasoline-powered generators are needed to supply 110-volt power to crews in the field. One or more should be available in a store room to be drawn by the crews as needed. Such generators are commonly used to provide lights for night work and 110-volt power to operate electric power tools.

A trailer-mounted, gasoline-powered generator is used to run the small- to medium-sized lift stations that do not have a permanent source of standby power when the usual source of power fails.

Truck-mounted generators that operate off the truck's electrical system also are available to provide 110-volt power. This equipment usually is permanently mounted to the truck. Large organizations provide selected trucks with this equipment when the need is great enough to warrant it.

ELECTRONIC LOCATORS

Equipment of this type will be required at some time by most maintenance and repair crews.

Many types of locators are available. Three common types are discussed below. The simple valve or lid locator is easy to operate, has a limited depth capability, and is most useful in locating buried manhole covers or water valves. Emergency crews in particular will find the valve locator effective in locating buried manhole covers. This unit is relatively inexpensive and one can be furnished as part of the permanent equipment that emergency crews carry on their trucks.

The pipe locator is a bit more complex, but simple to operate after it has been assembled. Pipe locators are capable of operating at greater depths than lid locators and are most effective in locating metal pipes, manhole covers, and water valves. Repair crews use a pipe locator to find underground utilities prior to excavation. It may not be practical to supply all crews with such expensive equipment, but one locator in a foreman's truck or in the tool room can be made available when needed.

The ferret-type locator is the most complex and capable of the most accuracy. It uses an electronic signal unit which can be floated or pushed down a sewer of any type material. The locating unit above the ground picks up a signal from the unit which is in the underground pipe, pinpoints its location, and in many cases indicates the depth of the pipe. Electronic and ferret-type locators do not work in metallic, cast iron or galvanized pipe. The ferret-type locator is relatively expensive and is limited to specific purposes. It may be of little use except to the larger maintenance organizations.

PLUGS

Plugs are available in two common types — air and mechanical. All crews should carry at least the common smaller sizes. As with sewer balls, larger sizes are less frequently used. They should, however, be available in the storeroom to be drawn and used by any crew when needed.

- Air plugs. These have the advantage of being inserted and inflated from ground level which makes it unnecessary for operators to enter the manhole.
- Mechanical plugs. Some models also are available that can be inserted and tightened from ground level. Other models require an operator to enter the manhole in order to insert and tighten the plug.

TAPPING MACHINES

The era of handmade taps into existing sewers hopefully has passed. This undesirable practice has been a major source of maintenance problems. Crude attempts to tap a sewer with hammers, chisels, and miner's picks often resulted in broken mains, ill-fitting taps, and taps protruding into the sewer. The resulting cracks and poor connections were inviting areas for future root intrusion and workers were often tempted to use an excess amount of mortar in an effort to hide the crude job. Many municipalities or agencies no longer allow tapping of the sewers by anyone other than their own operators.

There are a variety of tapping machines available which will produce an accurately sized, neat hole for tapping. Such machines also minimize the possibility of breaking or cracking the sewer during the tapping process. Most tapping equipment is adjustable to allow for use on a variety of pipe sizes of 6 inches and larger. The tapping machine is clamped securely in place on the sewer by attachments similar to a chain vise. A diamond-core drill of the exact size to accommodate the saddle safely provides a neat hole.

INTERNAL TAP CUTTER

Internal tap cutters were developed to remove protruding taps which resulted from former crude tapping methods. The cutter, which is slightly smaller than the sewer line, is pulled manually into the sewer to the location of the protruding tap. Two inflatable collars hold it securely in place. Using air power, the diamond-core drill is turned and slowly advanced until the tap has been neatly and safely cut off. This equipment is extremely useful when the offending tap is located in an area where excavation for removal would be impossible or very expensive.

BORING EQUIPMENT

Many large municipalities no longer permit cutting across major thoroughfares to install collection system service lines. Installation is impractical due to the traffic flow. In such areas boring equipment can be effectively used. Dig a boring pit at the edge of the right of way and another pit directly above the sewer line in the street. Make sure the two excavations, when connected, will form a 90° angle at the main line. Bore under the surface of the street and then install and connect the service line. Boring equipment is capable of cutting from 6-inch to 12-inch holes for distances of over 100 feet, and is available at a reasonable cost.

PIPE CUTTERS

Here again, hopefully, the era of the hammer and chisel has passed. A variety of chain-type cutters are available. All are capable of neat, safe, pipe cutting. Most cutters will provide the capability for cutting existing pipe in place in the pipe trench. Manual models are available for cutting smaller sizes of pipe, ratchet models for intermediate sizes, and hydraulic models for the larger sizes.

LINING EQUIPMENT

Special equipment for preparing polyethylene pipe used for slip-lining includes fusion joiner jigs, mobile carts to handle the pipe, a butt fusion tool and heating faces, tapping or coring tools, and accessories for the pulling heads.

FLOW MEASURING EQUIPMENT

Flow measuring equipment includes weirs, calibrated flumes, velocity meters, electromagnetic flow meters, and electronic velocity and depth recorders.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 398

12.4O Air testing equipment for detecting leaks in pipes and joints often is used to do what other jobs?

12.4P Where would you store equipment that is seldom used, such as large size sewer balls and portable emergency pumps?

12.4Q Name three different types of electronic locators.

12.4R What are the two different kinds of plugs?

12.4S Why should handmade taps be discouraged?

12.4T How can taps protruding into mains be removed?

12.4U How can a service line be placed under a major thoroughfare without disrupting traffic?

12.434 Safety Equipment

There is increasing concern by regulatory agencies that operators in the field of collection system maintenance be provided with safe work areas and equipment. Typically, it is the agency or supervisor who is held legally accountable for safety, not the operator in the field. But regardless of enforcement efforts by others, supervisors should be constantly concerned with the safety of their operators. A variety of safety equipment is available and its use must be required and enforced. (Also see Chapters 4 and 11 for safety procedures when working in and around manholes.)

ATMOSPHERIC TESTERS

A serious hazard faced by all collection system operators is the atmospheres to which they are exposed. Confined spaces such as manholes and wet pits can become deathtraps when a sudden change in atmosphere occurs. Three main items of concern are (1) lack of oxygen, (2) an explosive condition, and (3) toxic gases (hydrogen sulfide, chlorine). The only effective devices to detect such conditions are atmospheric testers.

A variety of single-purpose testers or meters are available and each one is designed to detect specific gases commonly present in collection systems such as carbon monoxide, methane, and hydrogen sulfide. See Chapter 11, Section 11.2, "Poisonous or Toxic Gases," for a more detailed discussion of gases and testing equipment.

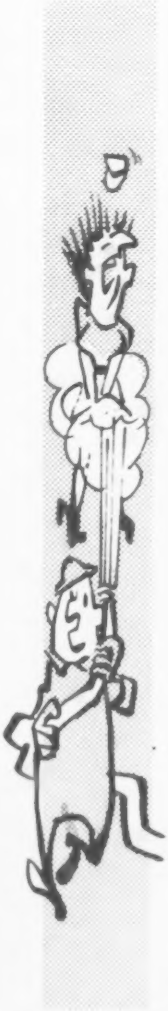
A dual-purpose meter capable of detecting either lack of oxygen or explosive conditions may be the most effective and practical detection device for most maintenance activities. See Chapter 4, Section 4.52, "Portable Atmospheric Alarm Unit," page 137 of Volume I, for more details.

Multiple-purpose testers have interchangeable parts that allow them to measure the level or concentration of several gases. For example, one instrument with interchangeable scales and calibration tubes can detect carbon dioxide, hydrogen sulfide, chlorine, sulfur dioxide and nitrogen dioxide. Another type of multi-purpose tester is capable of monitoring oxygen levels, explosive conditions (methane), and a toxic gas (hydrogen sulfide).

All types of testers should be equipped with both visual (light) and audible (sound) alarms that activate whenever the tester detects a hazardous condition. An operator should not be expected to read a dial or gage and then decide whether or not a hazardous condition exists. This is because the operator's physical senses and judgment can quickly become impaired by the hazardous atmosphere.

Consult the rules of the regulatory agencies in your area to determine the specific equipment you will need to meet their requirements and protect your operators. Regardless of such requirements, a supervisor should make available to any of the operators required to work in such confined spaces at least the testers capable of detecting a lack of oxygen, an explosive condition and any expected toxic gases (especially hydrogen sulfide). Continuous monitoring with such testers while people are working in confined spaces should be a basic safety rule for all maintenance organizations.

BLOWERS



In conjunction with the above detection meters, there also is a need to provide blowers of ample capacity to introduce fresh air into confined spaces. The recommended capacity range is from 4 to 20 volume changes per hour, depending on conditions in the confined space. Contact your local safety officer for the requirement.

At the very least, small, portable blowers should be standard equipment on all vehicles whose crews work in confined spaces. Blowers operating on the 12-volt power systems available in most vehicles are commonly used for this purpose. Larger maintenance organizations will usually need a trailer-mounted blower capable of up to 15,000 CFM air capacity. You will need such equipment whenever operators must enter large-diameter sewers for inspection or repair activities.

SHORING

Another hazard to underground collection system operators is the possibility of injury or death due to cave-ins while working in excavations. Adequate shoring must be provided for their protection. Many varieties of shoring are available. For additional information on shoring, read Chapter 3, Section 3.702, "Excavation and Shoring," page 72, Volume I; Chapter 7, Section 7.32, "Shoring," page 375, Volume I; and Chapter 11, Section 11.2, #12, "Excavations and Trench Shoring."

Hydraulic shoring. Hydraulic shoring is widely used, light in weight, and can be safely and quickly installed or removed while remaining above ground level.

Manual shoring. Manual shoring usually consists of screw jacks and wooden timbers of adequate size. Consult your area's regulatory agencies for the specific minimum size dimensions acceptable for shoring timbers. Installation of this type shoring is somewhat difficult and time-consuming, and operators are required to enter the excavation during the process of installation. Exercise caution! Make sure the top screw jacks are in place first, then proceed downward to the bottom of the excavation to offer the maximum protection to operators engaged in such installation. To remove the shoring, reverse the process. Remove the bottom jacks first and proceed upward. Obviously, because of these disadvantages, use of manual shoring should be limited to excavations of small size and depth.

Sheet shoring. Most regulatory agencies require this type of shoring in loose or running soil conditions. Exact dimensions acceptable for the sheeting will be specified by the regulatory agency in your area.

Cylinder and shield shoring. Cylinder and shield shoring are parts of prefabricated shoring that provide good protection for the operator and can save a lot of time over manual and sheet shoring methods.

Because modern shoring equipment is expensive and most organizations will have only a limited need for this type of equipment, it is common practice to purchase only the limited amount needed for most routine activities. When, and if, larger projects are undertaken, the required additional shoring can be rented for the required time.

TRAFFIC CONTROL

Traffic is a significant hazard faced by collection system operators that is frequently overlooked or underrated. In the interest of expediency, operators will often expose themselves to traffic flow without adequate protection. Supervisors should constantly impress upon their operators the danger of such practice. Make sure adequate equipment for traffic control is available and insist upon its use. Traffic control equipment includes:

1. Rotating, flashing beacons on vehicles,
2. Traffic cones and delineators,
3. High-level warning signs and flags, and
4. Fluorescent orange safety vests.

All maintenance vehicles should carry and use the above traffic control equipment (also see Chapter 4, Section 4.3, "Routing Traffic Around Job Site," page 116, Volume I; and Chapter 11, 11.2, #11, "Traffic Mishaps," page 18, Volume II).

PROTECTIVE CLOTHING

Collection system operators come into contact with a variety of hazards which make protective clothing advisable.

- Uniforms. Provide all operators with uniforms or coveralls to be put on at the start of the day and removed before going home. This practice will minimize the possibility of employees, who come into contact with raw wastewater in their work, wearing contaminated clothing home and perhaps exposing their family members to these contaminants. A uniform also identifies operators with your agency, which is especially helpful when access to private property is required.
- Safety shoes. Encourage all operators to wear safety shoes. Some organizations provide safety shoes and make it mandatory that they be worn. Other organizations may participate in a cost-sharing program with their employees to provide for safety shoes.

- Rubber boots. Employees who work in raw wastewater should be provided with safety toe, non-skid rubber boots, with a steel shank for protection of the bottom of the feet. Many organizations provide such protection on an individual basis or as needed.
- Gloves. Persons exposed to raw wastewater should wear protective gloves to eliminate or minimize cuts, abrasions and infection of broken skin.
- Eye Protection. Most operators will require eye protection of some type. A program for providing safety glasses, including prescription lenses, is desirable. Provide safety goggles to crew members exposed to flying particles, and supply complete face shield protection to crews working with chemicals.
- Hard hats. Hard hats should be furnished to all operators. They must be worn at all times on the job site.

- Ear protection. Ear protective devices must be worn when operating noisy equipment such as jack hammers.
- Portable ground fault interrupters. Interrupters should be used when operating portable electric tools, especially in wet locations.
- Safety harnesses. Harnesses should be provided to all persons who are working in manholes or inside large-diameter pipe. When such equipment is in use, there should be sufficient operators topside to provide for fast, safe removal of such persons should an emergency arise.
- Personnel hoist. A tripod set over a manhole with a rope running from a winch on one leg through a pulley at the apex to the safety harness of a worker provides a portable and effective method of removing a collapsed person from a manhole.

Aside from these common articles of protective clothing, other safety equipment may be required to meet specific conditions. Consult your area regulatory agency to assure that you are in full compliance at all times. Provide your crews with the necessary safety equipment and remind them frequently of the importance of safety. Give your operators complete instructions on the proper use of their equipment and insist that safe procedures be followed **AT ALL TIMES.**

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 398.

12.4V The atmosphere should always be tested before entering what kinds of areas?

12.4W What are the three main items of concern when testing the atmosphere?

12.4X Why must the atmosphere in a confined space be monitored continuously?

12.4Y How can fresh air be introduced into confined spaces?

12.4Z What common hazard is often overlooked or underrated by operators?

12.4AB Why must collection system operators wear protective clothing?

12.435 Office Equipment

The common office equipment required for the operation and maintenance of a wastewater collection system is beyond the scope of this manual. However, the following special office equipment is noteworthy.

BASE RADIO

A base radio is required when the vehicles of operating and maintenance personnel are equipped with two-way radios. If possible the base station should be part of a radio network covering all the public works agencies within the area served by the collection system. The station must be able to send and receive messages to the most remote part of the service area or be able to use a network's repeater facilities.

MICROCOMPUTER SYSTEMS

The increasing data processing power and declining cost of microcomputer systems now make it practical for superintendents of most wastewater collection systems to use computers. Large amounts of data can be rapidly processed into information that will help to operate and maintain collection systems efficiently.

Microcomputer systems consist of hardware that processes entered data and software that directs the processing. Microcomputer hardware includes a keyboard, a visual display screen, memory chips, a microprocessor, disk drives, and a printer.

Microcomputer application software (computer programs) fall into the following main categories:

1. Data base management,
2. Graphics,
3. Program development,

4. Spreadsheet analysis,
5. Telecommunications, and
6. Word processing.

Sub-categories of application software that could be used by the superintendent of a collection system are:

1. Accounting,
2. Application programs development aids,
3. Business management tools,
4. Capital projects planning and control,
5. Data management,
6. Graphics,
7. Inventory control,
8. Job and contract cost accounting,
9. Personnel management,
10. Programming utilities,
11. Purchasing accounts payable,
12. Time management and scheduling, and
13. Word processing.

In addition to the standard software packages that are available, several consulting engineering firms and specialty companies have developed software packages specifically for the management of wastewater collection systems.

Before purchasing microcomputer hardware and software, first analyze in considerable depth how a computer system will make the operation and maintenance of your collection system more efficient in a cost effective manner. It is important to know what you want the computer system to accomplish and then purchase the hardware and software that will do the job. The cost of hiring a qualified consultant to help you design and purchase a computer system will usually be offset by what you'll save in obtaining an effective system at the best price.

12.44 Management

Proper management of the equipment used to operate and maintain of a wastewater collection system will maximize its availability for productive work and extend its useful life. A superintendent should maintain an inventory of equipment, assign responsibility for its use and maintenance, record operating costs, and plan cost-effective replacement.

12.441 Inventory

An inventory record documents the equipment owned by an agency and provides information for its management. The inventory, in whatever physical form, must be kept current and accessible. The essentials of an equipment inventory record include:

1. Type (high velocity cleaner),
2. Model year,
3. Date purchased,
4. Cost,
5. Description,
6. Manufacturer, and
7. Fuel type.

12.442 Responsibility

Responsibility for each piece of equipment should be assigned to a person who will direct individuals or crews in efficient use of the equipment and will ensure that it is maintained in an operable condition. One person should be made responsible for the preventive maintenance and repair of all equipment. This person should also be responsible for recording the operating and maintenance costs for each piece of major equipment.

12.443 Preventive Maintenance and Repair

A good preventive maintenance program for equipment will be based on a system that indicates when and how each piece of equipment is to be maintained, when maintenance work was performed and the cost of that work. Good preventive maintenance will minimize the amount of equipment repairs. Repairs to equipment should be made in a timely manner to keep the equipment in a safe operating condition and to minimize down time.

Some wastewater collection agencies will be large enough to have their own equipment maintenance and repair section. Smaller agencies may have most of the maintenance and repair performed by contract. In either situation collection system personnel can be used efficiently to perform minor maintenance and repairs between normal jobs and during inclement weather conditions.

12.444 Replacement

Equipment should be replaced when it has reached the end of its useful life. Useful life can be defined as the time at which a piece of equipment ceases to perform its required work or when the cost of operating and maintaining the equipment is greater than the cost of operating and maintaining new equipment. Good records must be kept and the total cost of operating a piece of equipment, including amortization of its purchase cost, used in order to make an informed decision on its replacement. The financial impact of equipment replacement on an agency can be reduced by making regular payments into a sinking fund for equipment replacement.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 398.

12.4AC List the main categories of microcomputer software (computer programs) that could be used by a collection system agency.

12.4AD List the essentials of an equipment inventory record.

12.4AE When should a piece of equipment be replaced?

DISCUSSION AND REVIEW QUESTIONS

Chapter 12. ADMINISTRATION

(Lesson 3 of 7 Lessons)

Write the answers to these questions in your notebook before continuing. The question numbering continues from Lesson 2.

13. How would you determine the tool and equipment requirements for a collection system?
14. Discuss the advantages and disadvantages of the different methods of obtaining equipment.
15. Why must trucks be of adequate size?
16. How can seldom-used pieces of equipment be made readily available to all crews when needed?
17. What kinds of safety equipment are needed for each type of maintenance crew?
18. What is the basis of a good equipment preventive maintenance program?

CHAPTER 12. ADMINISTRATION

(Lesson 4 of 7 Lessons)

12.5 FACILITIES

Wastewater collection system operation and maintenance facilities consist of yards and shops, as well as buildings needed for storage of equipment and material, maintenance of equipment, assembly of operating personnel and the housing of staff personnel. Ideally all elements of the facilities should be located together at one site near the center of the area served by the collection system. If the service area is very large, causing excessive travel time from a central yard to remote areas, satellite yards should be considered. The decision to decentralize is based on a least-cost analysis. Some small and medium sized agencies locate their collection system operating and maintenance facilities adjacent to the treatment facilities for economic and administrative reasons.

In some instances, particularly when a collection system is under the jurisdiction of a multi-function agency, the upper levels of collection system staff will be housed along with similar staff for other divisions in an office building removed from the collection system yard.

12.51 Yard

A collection system's yard should be large enough to provide for its present and future uses. Having room to expand is particularly important if expansion of the collection system is anticipated.

12.511 Storage and Servicing Equipment

A yard is used to store equipment when it is not being used and to service it before use. Store equipment in a location that provides easy access and allows placement and removal of each piece in a safe and efficient manner.

Vehicles and special mobile equipment should be placed in a location that will minimize the need to back them in or out of their storage area. Usually it is most economical to store vehicles and special mobile equipment in open areas. However, roofed areas or completely enclosed areas may be appropriate if heavy rainfall or snowfall would shorten the useful life of equipment or make it operationally unreliable if stored in the open. Generally, small pieces of equipment and equipment not mounted on vehicles are stored in buildings.

A yard should provide for the servicing of vehicles and engine-driven special equipment with fuel, air, coolant and oil when needed. Facilities for the frequent washing of the vehicles and special mobile equipment should also be provided. Small agencies often find it uneconomical to have their own service facility and use a nearby service station instead.

12.512 *Storage of Materials*

The materials needed for the operation and maintenance of a collection system that are not readily available from a supplier should be stored in an agency's yard. Such materials include chemicals, manhole barrels, cones, frames and covers, cleanout frames and covers, sewer pipe and fittings, brick, gravel, sand, cement and paving materials. The material should be stored in accessible locations and contained in appropriate bins and enclosures. Hazardous materials, such as toxic chemicals and flammable fuels, must be stored safely and in accordance with local regulations. The manner of all material storage must provide for safe and efficient movement in and out of its area by hand or with appropriate equipment.

12.513 *Training Area*

Yard space should be provided for the training of collection system operators in the efficient and safe use of equipment and materials. Large agencies will have the resources to construct specialized facilities for training collection system operators. One such agency constructed a six-inch diameter sewer above ground using clear plastic pipe and terminal manholes. The facility allows operators to observe the cleaning action of balling and high velocity cleaners in sewers.

12.514 *Security*

The yard should be completely fenced to restrict entry by unauthorized persons and lighted at night to discourage theft or damage of valuable equipment. Completely lock all vehicles and mobile equipment and store the keys in a secured cabinet. Store small equipment and valuable tools and materials in a locked enclosure. A written inventory of equipment, tools and valuable materials that is kept up-to-date will discourage their "unexplained loss."

12.52 Shop

Shop facilities will vary from a small area in a building equipped with a work bench and a few tools, when an agency is operating a small collection system, to a large shop building equipped with an array of hoists, overhead cranes, machine tools, power tools, welders and other devices, if the agency is operating and maintaining a large collection system with many lift stations.

12.521 *Location*

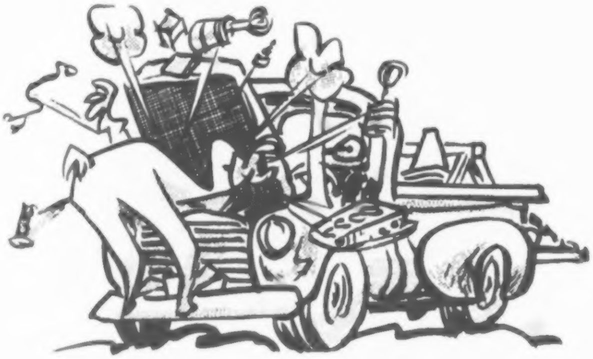
Select a location for the shop facilities that will allow the efficient movement of the items to be worked on in and out of the shop. Also, the shop location should not interfere with the movement of other equipment and materials stored in the yard. The shop area in a building should have smooth concrete floors that can be easily cleaned. Ceiling heights and door openings must allow clearance for the largest item to be worked on. Good lighting and ventilation are required, especially for welding or painting work. In cold climates the shop area should be heated to a comfortable temperature. Adequate ventilation and air conditioning should be included in warmer climates.

12.522 *Equipment*

A superintendent responsible for equipping a shop should first determine what work will be done in the shop and then select the equipment and tools needed to do the work. Try not to over equip a shop initially as this leads to a lot of unused equipment and tools laying around. It is easy, and more economical, to purchase equipment and tools as you find you need them. As you study the other chapters of this manual, envision the equipment and tools you think would be needed in a shop.

12.523 *Use*

Use of the shop area should be limited to authorized personnel. Small and medium-sized collection system agencies will authorize qualified collection system operators to work part-time in a shop. Large agencies will probably hire full-time shop personnel. In either situation, personnel authorized to work in shops must be qualified to operate the shop equipment in a manner that will not damage the equipment nor injure the operator or co-workers. Authorized shop personnel must be held responsible for returning equipment and tools to their proper locations and for keeping the shop area clean and in a safe condition.



Valuable shop equipment and tools should be inventoried and secured in an enclosed tool room with one person responsible for checking items in and out. The entire shop area should be secured when authorized shop personnel are not in the immediate area and at the end of work shifts.

12.53 Operator Facilities

Full-time collection system operators need facilities where they can prepare for work assignments at the beginning of a work period and for departure at the end of a work period. Ideally, the operators' facilities will be close to where they park their private vehicles and near the equipment they will be using to perform their work.

12.531 *Hygienic Facilities*

Collection system operators should be encouraged to practice good personal hygiene. The collection agency can do this by providing some or all of the items described in the following paragraphs.

LOCKER ROOM

A well lighted and ventilated room should be equipped with individual lockers and benches for the changing from street clothing into protective clothing at the start of a work period and the reverse at the end of a work period. The room should also provide facilities for storage of clean protective clothing, soiled protective clothing, and special outer wear such as rain gear and rubber boots. For hygienic reasons, protective clothing must not be worn home.

LAVATORIES AND TOILETS

Lavatories, preferably the circular, foot-operated type, should be installed in a room adjacent to the locker room but partitioned off or in a room separated from toilets. Local building codes will specify the minimum number of lavatories and toilets that are required for the number of persons using the facilities.

SHOWERS

Showers should be available to collection system operators in a room adjacent to the lavatories and toilets. An agency cannot require collection operators to shower after working in an environment that exposes them to wastewater, but it can encourage this practice by providing pleasant facilities and furnishing towels. Shower facilities will be essential when an operator is accidentally covered with hazardous chemicals or wastewater.

OUTER WEAR WASHROOM

If practical, a small room (at the entrance to personnel facilities from the yard) should be provided for the washing off rain gear and rubber boots that are muddy or covered with residue from sewer cleaning. The room should contain a floor drain, a water faucet and a hose.

12.532 Assembly Room

An assembly room for collection system operators should be provided adjacent to the locker room. The room should contain tables, chairs, a blackboard, bulletin board, and an area for personal equipment such as gas detection devices and hand-held radios. The room and furnishings should accommodate the number of persons that need to be assembled at the same time for the purpose of making assignments, giving instructions, and training.

12.533 Employees' Room

A pleasantly decorated room for refreshment and meal breaks should be provided for the collection system operators who are permanently assigned to work in the yard area and for collection system operators who are occasionally in the immediate area. It should contain a sink with hot and cold water, microwave oven, refrigerator, coffee urn, and tables and chairs. If practical, the room should have windows that open onto a landscaped area.

Small and medium-sized agencies may, for economic reasons, use the assembly room as an employees' room by the adding a food and drink preparation area to the room. If this is done, extra care must be taken to keep the assembly room clean and free of contamination from wastewater residue brought in by field personnel.

12.54 Offices

The administrative staff of a collection system needs offices that provide them with adequate facilities for the efficient performance of their duties.

12.541 Location

Staff offices may be located entirely within the same building as the operator facilities, or the top level managers may occupy a separate building. In either situation, the offices of supervisory personnel should be in the same building and near the operators' assembly room since a supervisor must have daily contact with operators.

12.542 Types

Private offices are usually provided for superintendents and assistant superintendents. Supervisors may have private offices or may be located in a room shared with other supervisors. Supporting staff (such as secretaries, clerks and technicians) generally have work areas within a common room. Movable partitions in a common room provide some privacy and reduce distractions caused by the separate activities taking place in the room. Dispatchers may be located in a separate room where the audible radio communication will not cause a distraction for other workers.

12.543 Ancillary Facilities

In addition to staff offices, an administration building will need the ancillary facilities described in the following paragraphs.

RECEPTION AREA

A pleasant visitor reception area should be located at the front of the main office building and contain seating for waiting visitors, information about the activities of the collection system department, and a clerk-receptionist.

EMPLOYEES' ROOM

If the staff offices are separate from the building containing the employees' room for operators, a separate employees' room should be located in the main office building. The room should contain the same furnishings as the employees' room for the operators.

RESTROOMS

Restrooms must be provided for both men and women. Local building codes regulate the number of lavatories and toilets to be provided for the number of employees using the building.

COMPUTER ROOM

If several staff members share the use of computer terminals and printers, it may be desirable to locate the equipment in a separate room to facilitate use by different people and to minimize the noise distraction for other workers.

STORAGE ROOM

A storage room should be provided for office materials, temporarily unused equipment and archived records.

LIBRARY AREA

Either a separate room or a convenient area with ample book shelves should be provided for storage of books, bound reports, catalogs, technical references, and training manuals.

SECURITY

Fireproof vaults and files are recommended for storage of valuable papers and records. Computer backup disks and tapes should also be stored in a fireproof vault or, preferably, in a convenient bank's safe deposit box. Key your locks so that one key opens all outside office building doors. Issue copies of the key only to selected personnel who need access to the buildings. Keep a record of keys issued and returned. Periodically change the lock tumblers and issue new keys for good security. At night, illuminate dark areas outside and inside the office building to discourage loitering and unauthorized entry.

12.55 Landscaping

Landscaping the fringes of the collection system maintenance yard and office building setbacks will make the facilities pleasing to the public and visitors and will increase the satisfaction of employees for the agency. The landscaping should be appropriate for the environment and not require extensive maintenance. Use automatic irrigation systems to conserve water and reduce maintenance costs.

12.56 Parking

Provide parking spaces for operators and staff personnel near the assembly and office buildings and arrange for convenient visitor parking near the entrance to the main office building. Landscape parking areas and illuminate them for added security.

12.57 Design

It is advisable to consult with architects and engineers during the design and construction of collection system facilities in order to produce an efficient and pleasant-appearing facility. However, it is even more essential that the superintendent and the operators be involved in the design process to ensure functional facilities. They are the ones who are most familiar with the activities that will take place in the facilities, and their experience should not be overlooked.

QUESTIONS

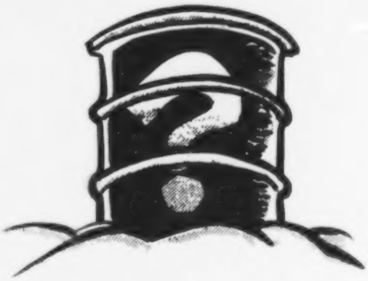
Write your answers in a notebook and then compare your answers with those on page 399.

12.5A What kinds of service should be available in the maintenance yard for vehicles and engine-driven special equipment in a maintenance yard?

12.5B What types of hazardous materials could be stored in a maintenance area?

12.5C How should valuable tools and equipment be secured in the shop area?

12.5D Why is it important to landscape around the collection system maintenance yard and office buildings?



DISCUSSION AND REVIEW QUESTIONS

Chapter 12. ADMINISTRATION

(Lesson 4 of 7 Lessons)

Write the answers to these questions in your notebook before continuing. The question numbering continues from Lesson 3.

19. Under what circumstances should a satellite maintenance yard be considered?
20. What materials needed for collection system operation and maintenance should be stored in an agency's yard?
21. Why is security of a maintenance yard important?
22. What types of hygienic facilities should be available for collection system operators in a maintenance yard?
23. Why do collection system operators need an assembly room?

CHAPTER 12. ADMINISTRATION

(Lesson 5 of 7 Lessons)

12.6 MAPPING

Maps are absolutely essential to the operation and maintenance of any wastewater collection system. Maps showing the accurate location of the components and an indication of the size of the collection system will be required before any maintenance activities can be planned or implemented. As a collection system grows, staffing will increase, maintenance activities will expand, and a corresponding need for better, more detailed maps will become evident. Maps must indicate what has been constructed, where, what size, the materials used, and the conditions encountered. A detailed record or documentation of what is underground is critical for the successful operation and maintenance of a wastewater collection system.

12.61 Importance of Mapping

Under certain conditions it might be possible for one collection system operator to operate a small collection system without the benefit of any formal map system. In time, the operator could become familiar enough with the collection system to operate from memory. This practice is not recommended, regardless of how small the collection system. Inevitably, at some time, this operator and the operator's memory will be unavailable. When that time comes, the operator's replacement will have many problems.

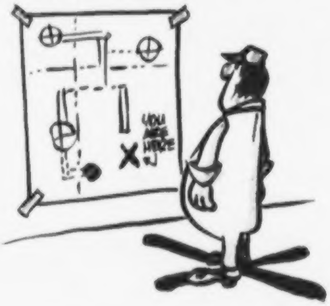
Collection systems of a significant size present an entirely different situation. The number of operators involved will make it impossible for each of them to become thoroughly familiar with the entire collection system. Daily assignments will send operators to parts of the system they may never have seen or even knew existed. Maps will be needed for the daily function of directing operators to their assigned work areas.

12.62 Information on Maps

12.621 Locations

Collection system maps should provide the information staff and operators need to plan and conduct operational and maintenance work. To be most useful, maps will show system components in relation to other fixed landmarks.

- Main, Trunk and Interceptor Sewers. The location of these sewers in streets are shown in relation to the center line or property lines. Sewers in easements are shown in relation to property lines and the width of the easement is noted. Curved sewers are shown in relation to a straight line between the beginning and ending of the curve; the end points of the line are then shown in relation to either the downstream or upstream manhole.



- Building Sewers. Show the distance in feet between the downstream manhole and the connection of the building sewer to the main sewer. Also, indicate on the map the distance along the property line between the sewer crossing and one of the property corners.
- Manholes. Care should be exercised to indicate manhole locations accurately, by footage from connecting manholes and by scale in relation to property lines and property corners. This is especially important because considerable time can be lost in seeking manholes that have been paved over in streets or covered by landscaping, regrading or vegetation growth in rear easements.
- Cleanouts. Collection systems will contain many fewer cleanouts than manholes. However, when you need access to a plugged sewer, cleanouts become equally essential. Being smaller in size and metal mass, they are more difficult to find by sight or by electronic locators. For these reasons, take care to accurately designate their locations on maps.
- Boundaries. Jurisdictional boundaries of surrounding agencies also should be shown.

12.622 Identifications

Aside from location, identification by number is the next most important benefit to be realized from good maps. Accurate number identification will provide the basis for an accurate record system. Use specific numbers to identify the items listed in the following paragraphs.

- Manholes. Each and every manhole should be assigned a specific, permanent identification number and these numbers should never be changed. When extensions of a collection system result in the addition of manholes, each addition must be recorded on maps immediately in order to keep the maps current. It is the responsibility of management to provide a means of insuring that maps are kept current and periodically checking to be sure the map updating is done.

Occasionally, those who draft maps succumb to the temptation of assigning new numbers to existing manholes in the interest of keeping a particular portion of the map neat and sequential. Such practice will make all existing records useless because they are based on original numbers. Additional manholes, when recorded on the mapping system or page of the mapping system, must always be assigned new numbers. To avoid having manholes with high numbers, start numbering the manholes on each page with the number 1. Different agencies have different procedures for numbering manholes and any procedure is satisfactory as long as it is simple and not confusing.

- Sewer Cleanouts. As with manholes, cleanouts are identified by their own specific number.

- Sewers. Each section of sewer between manholes is identified or designated as an individual section. This individual section can be identified simply by indicating the numbers of the two manholes which the section connects.
- Properties Served. Identify all individual parcels of property which are connected or have the potential of being connected to the collection system. The street address and lot number or the assessor's parcel number are commonly used for identification.
- Cleanouts at Property Line for Building Services. Specific identification, by individual number and location, is a matter of choice depending on the scope of a particular recordkeeping system. Cleanouts are commonly identified by reference to the particular parcel of property they serve.

12.623 Elevations and Depths

Known elevations are vital to the operators of gravity wastewater collection systems. Essential elevations that should be shown on maps are:

- Flow Lines. Maps should indicate flow lines, also called inverts, at the site of each manual for all sewers entering and leaving the manhole.
- Manhole Rim Elevations. If rim elevations are not shown, then the depth of manholes should be indicated. Rim elevation can be computed by adding manhole depth to invert elevation.
- Depth of Building Sewer at Property Line. Often this depth is not recorded on maps or construction plans. Many local construction codes merely stipulate a minimum and maximum acceptable depth, except in cases of unusual topographical conditions. If possible, or practical, a good practice would be to accumulate and record all such depths measured during the normal course of inspection, maintenance or repair activities. This information would then be available to be included in future updating of maps.

12.624 Lengths and Widths

Lengths and widths that should be shown on collection system maps include the following:

- Show the length of sewer lines in feet between the centers of downstream and upstream manholes. Some maps will show a surveyor's stationing of the upstream manhole from the downstream manhole; the length of sewer line is obtained by converting the station designation to feet. For example, if a manhole has a 3 + 52 station designation, the length of sewer line between manholes is 352 feet.
- The lengths of all property lines shown on the maps and the widths of all mapped streets and easements should be shown in feet.

12.625 Other Information

In addition to locations, identifications, elevations, and lengths and widths, the following information should appear on the maps:

- Flow Direction. The direction of flow in main, trunk and interceptor sewers should be shown by a directional arrow.
- Force Mains. This type of sewer line should be specifically designated since it requires special maintenance.
- Scale and North Arrow. The scale of a map must be shown so distances measured in inches on the map can be converted to feet of distance in the field. A north arrow on the map allows it to be oriented or pointed in that direction in the field.
- Dates. The date that each map page was drafted and the date of the last revision should appear near the border of the map.

12.626 Optional Information

Some sewer collection agencies may include the information in the following paragraphs on their maps.

- Types of Pipe. The type of pipe used to construct a sewer line is shown on the map using the following designations: ABSP - Acrylonitrile Butadiene Styrene Pipe; ACP - Asbestos Cement Pipe; CIP - Cast Iron Pipe; CMP - Corrugated Metal Pipe; PVCP - Polyvinylchloride Pipe; RCP - Reinforced Concrete Pipe; RPMP - Reinforced Plastic Mortar Pipe; and VCP - Vitrified Clay Pipe.
- Soil Conditions. This information is not often shown on maps. Unusual soil conditions would be of great importance and a significant safety factor to future repair crews who would be re-excavating in disturbed ground. Such information could be acquired at time of construction and noted on "as-built plans" by inspectors. Soil conditions could then be included in any future updating of maps.
- Properties Connected to Collection System. This information may not be available when maps are originally compiled. Properties connected should be added at the time of connection. An ideal method is to record connection permit numbers, as soon as they are issued, on tracings of map system.
- Inventory. Inventory listing should include the number of manholes, flusher branches, house connections and footage for each size pipe. This may not to be practical on large maps covering large areas because of the huge totals required and the small scale of such maps. Inventory totals can and should be computed when maps have been divided into sections or pages. On such maps of adequate scale, totals for each page or section can be easily computed and can be easily added together to provide the total for each book or map (which are divided into sections). By adding these book totals or map totals, the total for the entire collection system can be determined. Computer technology can also be used to create and maintain an inventory of facilities, and in many instances, more efficiently than by the method described above.

QUESTIONS

Write your answers in notebook and then compare your answers with those on page 399.

12.6A Why are maps of a wastewater collection system important?

12.6B List as many items of information as you can recall that should be available on wastewater collection system maps.

12.6C How should manholes be identified on maps?

12.6D What elevations should be shown on maps?

12.6E Why should soil conditions be shown on maps?

12.63 Type and Size of Maps

For the collection system operator in the field, an ideal map would be one drawn for your specific use and needs. It would provide all the details possibly needed, on a scale large enough to be easily read, and of a size that would be convenient and easily handled in the field in all kinds of weather. Unfortunately few, if any, maps can meet all these requirements.

Developing a mapping system for the sole purpose of field use is rarely done due to the costs involved. However, by using various types of available maps and adapting them to fit most of our needs, it is possible to provide collection system operators with mapping systems that are functional. Common types of use maps that are useful include:

- Area Maps. Most agencies, regardless of size, will compile a map showing how the entire area is served by its wastewater collection system. Such maps usually outline only major components including major trunk lines, pumping stations, treatment plants and major thoroughfares, and the relationship of these parts to communities, districts, water courses and streams.
- Master Maps. The size of your service area will determine how many maps you will need. A small system may require only one map. Large areas obviously will need more maps. A master map may be needed for each community or district within the whole area. Master maps should be drawn on a scale capable of indicating at least the approximate location of the collection system (including manholes) in relation to all streets and properties within the area.
- Section Maps. These become available whenever master maps are divided into sections. They should be drawn to a scale that will allow more detail and be of a size practical for use in the field. The scale should provide ample space to clearly show identification numbers, footage and pipe sizes.

  The master and section maps may be combined for small and medium-sized collection systems.
- Base Maps. In most areas, the county assessor or real estate department maintains an accurate and up-to-date mapping system. It is their responsibility to keep accurate, legal records on each individual parcel of property. Usually their maps are divided into pages and the pages bound into books. Base maps such as these provide a scale adequate for detailed information and included recorded right of ways, street names and widths, property identifications and sizes. These map books, being of a size suitable for field use, are ideal for a maintenance department to adopt and adapt as the basis of collection system maps. Tracings of these maps usually can be obtained from the originating department and you can overlay your collection system on these tracings.

12.64 Mapping Coordinates

All states have developed a state coordinate system. Surveyors developed the state coordinate system for the purpose of connecting all their surveys, such as land surveys and highways surveys, to the same reference stations. Should monuments which mark land corners or other reference points ever be destroyed, they may be readily and accurately reestablished on the basis of their coordinates and a new survey originating at other stations in the network.

If all utility agencies (water, wastewater, gas, telephone, electricity) identified the location of all the important points of their underground facilities on the same coordinate system, our jobs requiring excavation would be much easier with respect to the location of other utilities. Even after floods or hurricanes, or during periods of heavy snow, a grid coordinate system would help locate underground utilities and expedite the return of utility systems to service. A goal for every wastewater collection agency could be to have their engineer or surveyor develop and implement a plan for all utility agencies to map their underground systems using the same grid coordinate system.

Whether an agency is part of a state coordinate system or a local system, the procedures for identifying and locating facilities are similar. Both systems use two sets of parallel straight lines running east and west and also north and south (Figure 12.1). The resulting network is called a GRID. Grids are bordered on the south by the AXIS OF X and on the west by the AXIS OF Y. Distances along both axes are measured in feet. The point of intersection of these axes is called the ORIGIN OF COORDINATES.

The position of a manhole or other facility represented on the grid can be identified by stating the two distances termed COORDINATES. One of these distances, known as the X-COORDINATE, gives the position in an east-and-west direction (Distance X' on Figure 12.1). The other distance, known as the Y-COORDINATE, gives the position in a north-and-south direction (Distance Y' on Figure 12.1).

Since surveyors have already established state grid systems in every state, wastewater collection systems can be identified with the state system by surveyors or civil engineers. Other utility agencies such as water, gas, electricity, telephone, drainage, roads and streets, may or may not be using your state grid coordinate system; but their facilities, if shown on collection system maps, can be identified by the same coordinate system used for the maps.

Many cities and counties have determined the coordinates of the intersection of street and road centerlines. If the distance and direction of a manhole from a centerline intersection is measured, the coordinates of the manhole can be calculated easily. For example, Figure 12.1 shows that the coordinates of an intersection of two street centerlines are 828,376.24 and 106,249.01 and the measured distance of a manhole from the intersection is 8.25 feet at an angle of 30°-15' from the east-west centerline. Knowing this information, the x and y distances of the manhole from the intersection can be calculated in the manner shown below using a pocket calculator.

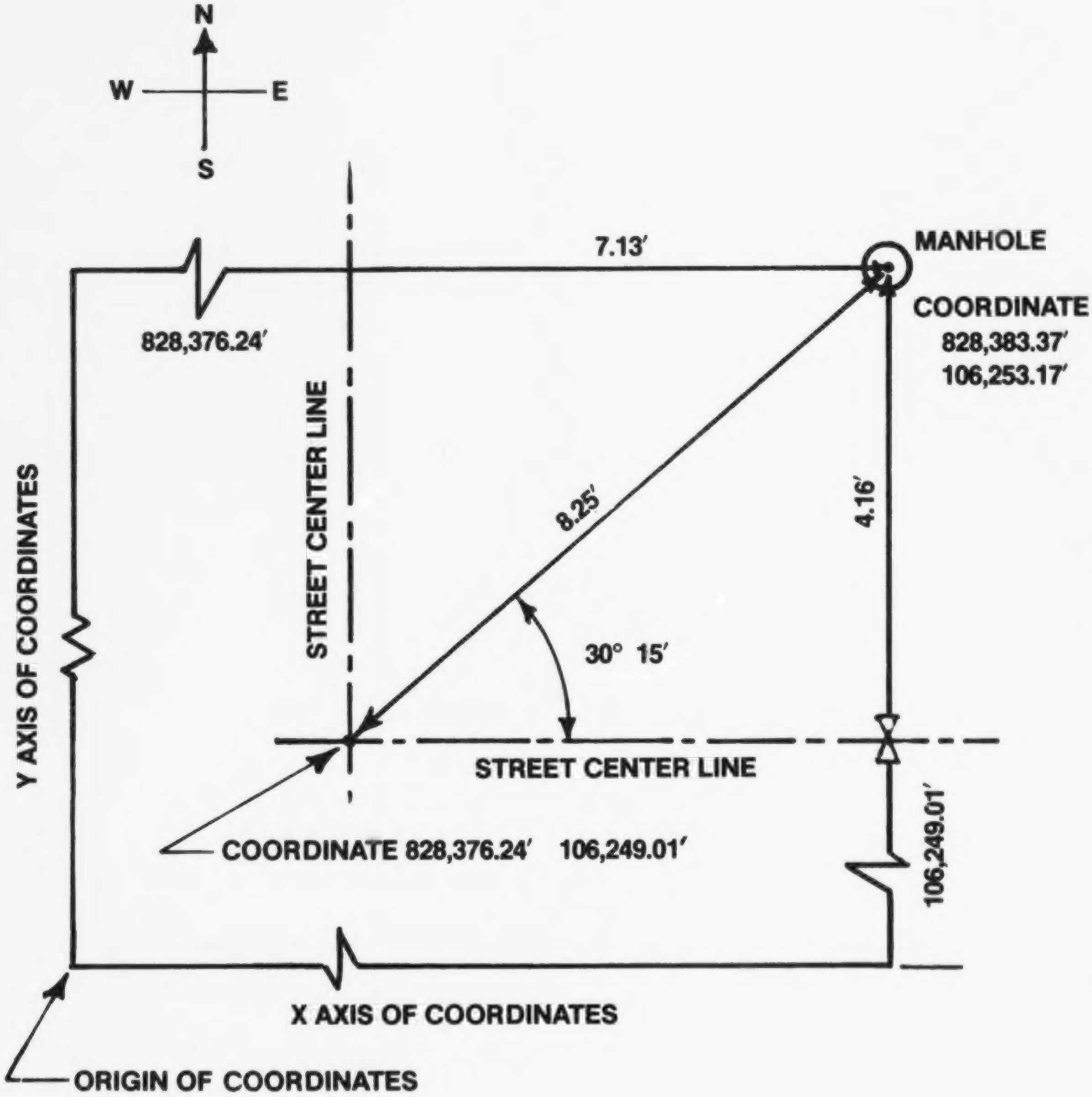

N
W
E
S
7.13′
MANHOLE
COORDINATE
828,383.37′
106,253.17′
828,376.24′
STREET CENTER LINE
Y AXIS OF COORDINATES
8.25′
4.16′
30° 15′
STREET CENTER LINE
106,249.01′
COORDINATE 828,376.24′ 106,249.01′
X AXIS OF COORDINATES
ORIGIN OF COORDINATES

Fig. 12.1 Grid coordinate system

Distance, x, ft = (8.25 feet) (cos 30°-15')
= (8.25 feet) (0.8638355)
= 7.13 feet

Distance, y, ft = (8.25 ft) (sin 30°-15')
= (8.25 ft) (0.503774)
= 4.16 feet

x coordinate of manhole = 828,376.24 + 7.13
= 828.383.37 feet

y coordinate of manhole = 106,249.01 + 4.16
= 106,253.17 feet

If every utility agency would use the state grid coordinate system, key points on any agency's underground facilities could be located on maps by coordinates and their separating distances computed. With everyone using United State Geological Survey (USGS) benchmarks for elevations, the elevations of underground facilities could be computed, too.

12.65 Examples of Mapping

Because of their scope and the many details needed in any mapping system, it is difficult by mere descriptive words to effectively illustrate the makeup of a good map. Included are three samples that should provide a clearer picture of information required on maps.

MASTER MAP

Figure 12.2 illustrates a small section of a master map that was drawn to a 1" = 800' scale. The total size of the entire map measures 4' x 4' and depicts one sanitation district serving a population of 55,000 people. If no other map was available, it could be used by collection system operators in the field. This map would, however, have some disadvantages. Its size makes it difficult to use. In the field it would be worn out by continued rolling and unrolling or repeated folding and unfolding. Frequent replacement would probably be necessary. The scale makes it difficult to read and provides too little space for necessary details and identifications.

SECTION MAP

Figure 12.3 illustrates a portion of one sectional map of a master map that was divided into 24 sheets. Each sectional map measures 2'x 3'. Drawn on a scale of 1" = 400', it has ample room for more detail and is easier to read. Used a map at a time, it could be suitable for field use. It would, however, be subject to the same handling problems as the master map.

BLOCK MAPS

Figure 12.4 is the most detailed of the three sample maps. Drawn to a scale of 1" = 100', it includes almost all the desirable items outlined in Section 12.62, "Information Required on Maps." Consult the Scale: 1" = 800' before reduction legends shown in Figures 12.5 and 12.6. They will enable you to interpret the information included on the block map. The actual size, 12" x 18" when bound into books, makes it ideal for field use. Protected by hard covers, it is very durable and will last for years during everyday use in the field. Damaged or updated pages can be replaced on a page-by-page basis.

The example shown here is one page of one book. The complete set totals 128 books, covers a county-wide collection system of 1,500 miles of sewers, and serves of population of 400,000. Map books can be easily carried and safely stored in one compartment of a utility truck commonly used by maintenance departments. Although block maps may contain more information than needed to perform a specific task, they do provide important information for the overall operation and maintenance of a wastewater collection system.

12.66 Preparation and Revision

Preparation and revision of maps for the operation and maintenance of wastewater collection systems are usually done by the engineering department of an agency. However, it is essential for the superintendent to be involved in this process to ensure a product that will be an aide to the efficient operation and maintenance of the system.

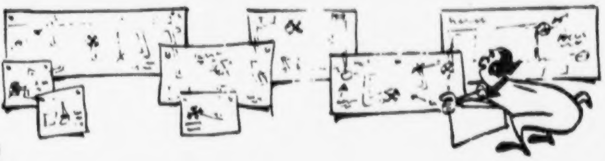
12.661 Preparation

Property maps described previously are used as the basis of the collection system maps. As-built plans are used to obtain the collection system information that is drafted onto the property maps. If as-built plans are not available, field surveys will have to be made to determine the information needed for mapping the system.

An agency with multiple functions, such as a city, may have one series of maps that provides comprehensive information on wastewater collection, storm drainage, water and other systems operated and maintained by the agency. Some agencies are using computer and aerial photographic technology to develop their mapping systems. The CAMRAS technique developed by the American Public Works Association is used for this purpose. Although the initial cost of computerizing hard copy and other mapping data can be high, there are many advantages to a computerized mapping system, including long-range savings for map additions and revisions and the ability to vary the form of reproduction to meet special needs.

12.622 Revisions

To remain functional, a mapping system must be kept as current as possible. Accurate and up-to-date maps can reduce time-consuming and costly mistakes. Suggested methods of accomplishing this are described below.



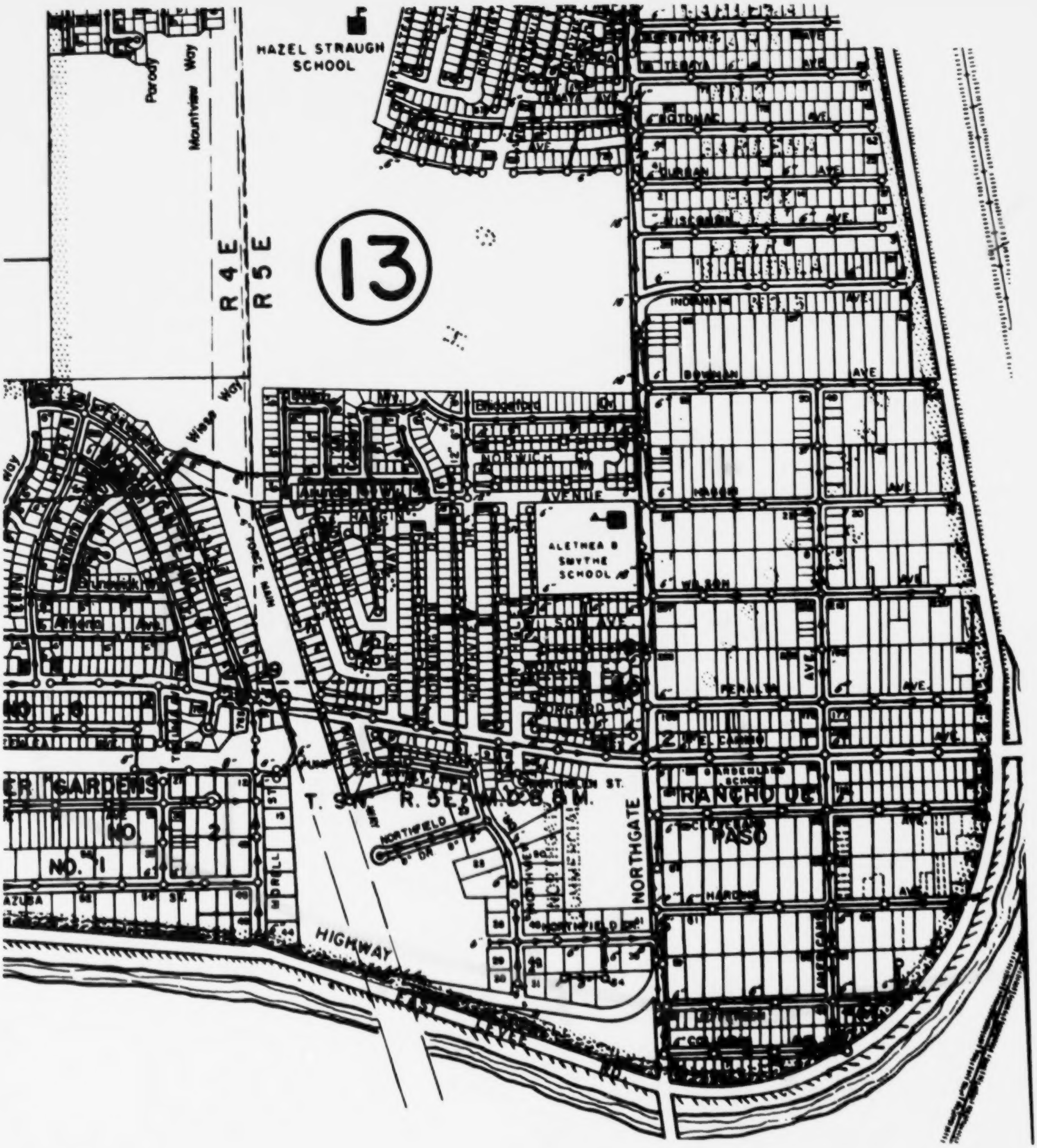

HAZEL STRAUGH SCHOOL
Parody
Mountview Way
R 4 E
R 5 E
13
Wise Way
NORWICH
AVENUE
ALETHEA B SMYTHE SCHOOL
INDIANA
BOWMAN
AVE
WILSON
PERALTA
GARDENS
NO. 1
NO. 2
T. 9N. R. 5E. M.D.B.&M.
NORTHFIELD
NORTHGATE
COMMERCIAL
HIGHWAY
RANCHO DEL PASO
HARDING
AVE
MORRELL ST.

Fig. 12.2 *Master map*

Scale: 1"=800' before reduction

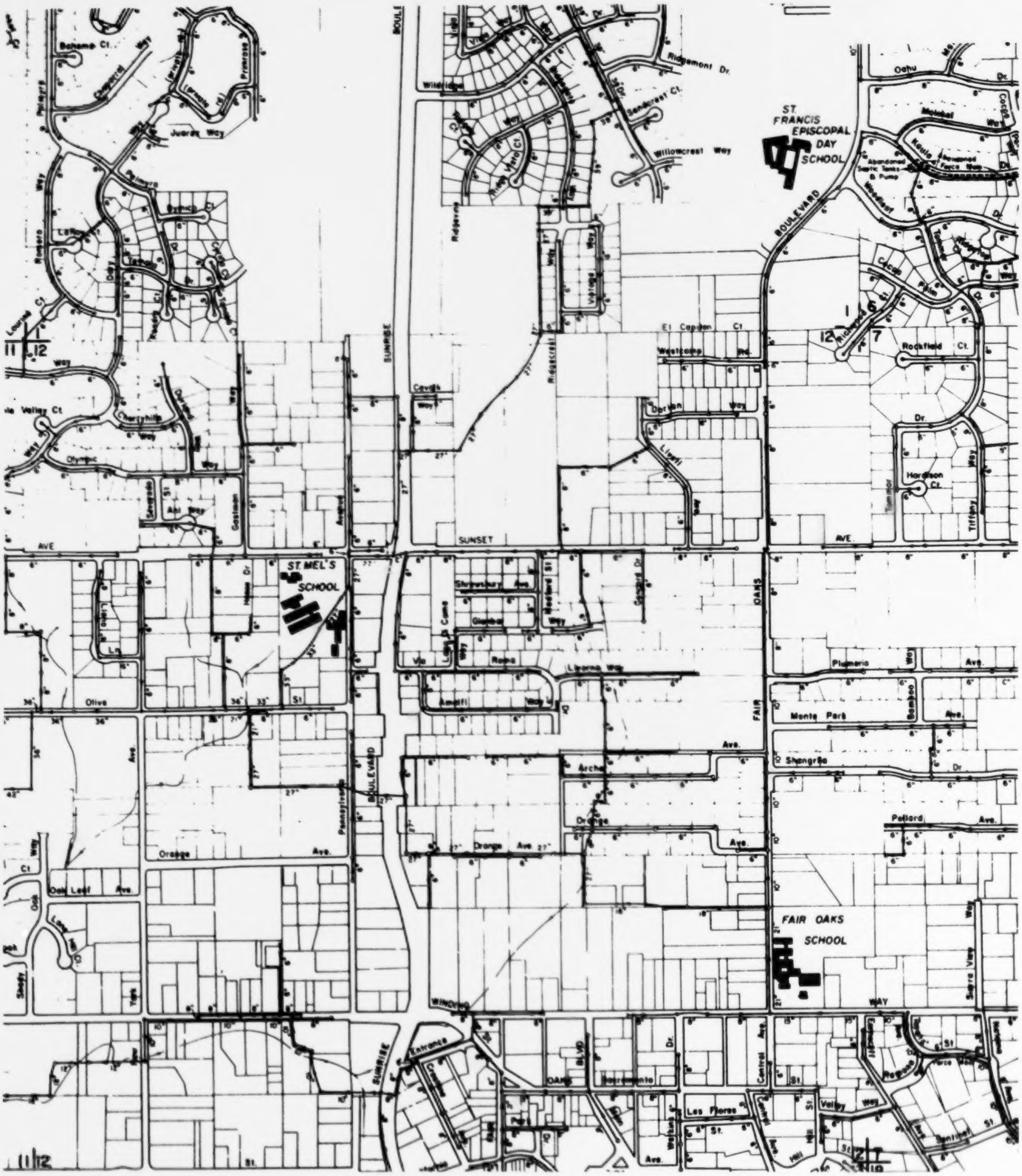
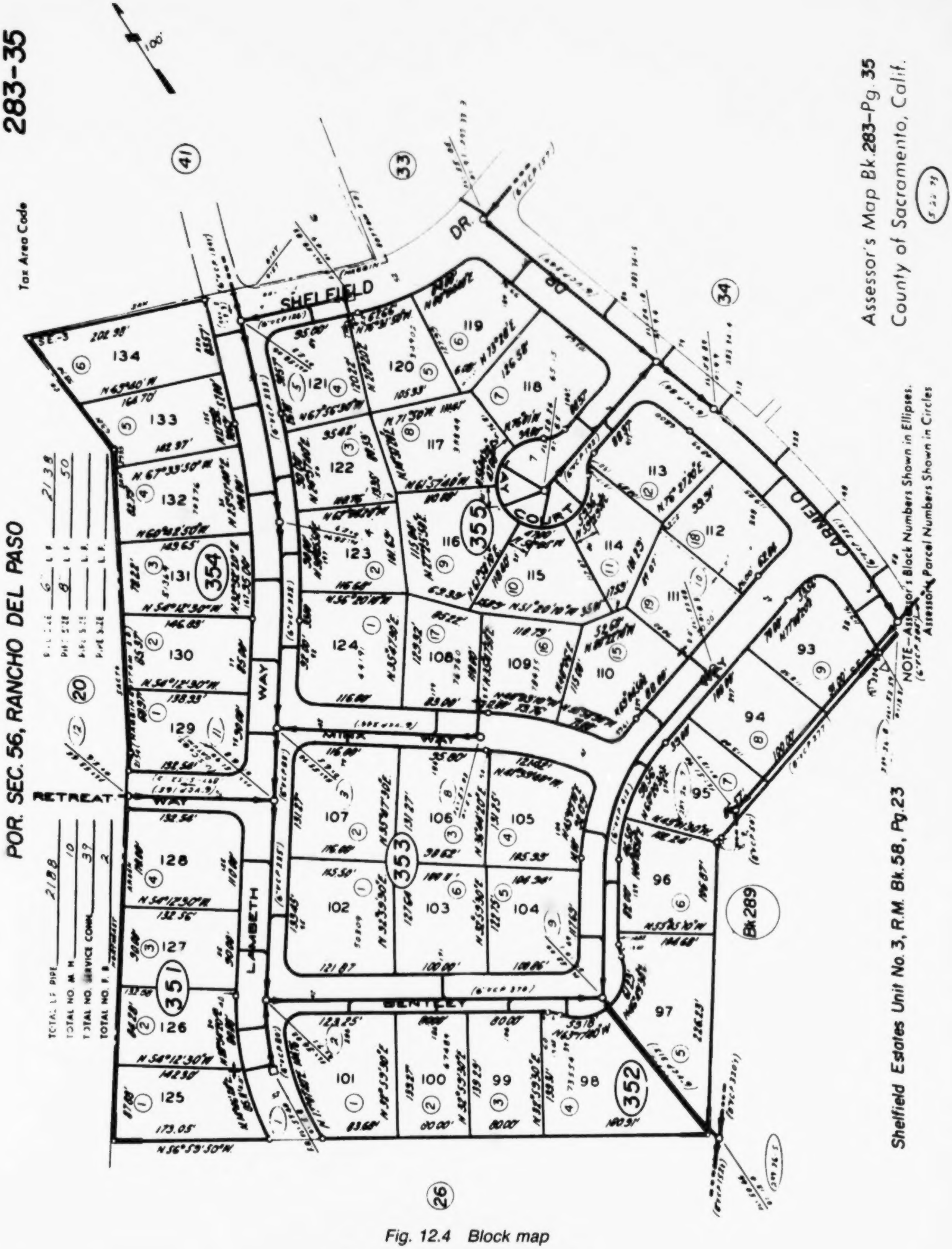

ST. FRANCIS EPISCOPAL DAY SCHOOL
ST. MEL'S SCHOOL
FAIR OAKS SCHOOL
SUNRISE BOULEVARD
SUNSET AVE.
FAIR OAKS BOULEVARD
Olive
Orange Ave.
Winding Way
Ridgemont Dr.
Willowcrest Way
Ridgecrest
El Capitan Ct.
Westcomb
Dorsey Way
Rockfield Ct.
Plumeria Ave.
Monte Park Ave.
Shangrila Dr.
Pollard Ave.
Pennsylvania
Oak Leaf Ave.
Archer Ave.
Orange Ave.
Amalfi Way
Oahu Dr.
Sacramento
Les Flores
Central Ave.
Entrance
OAKS BLVD
11 12

Fig. 12.3 Section map

Scale: 1" = 800' before reduction


283-35
Tax Area Code
POR. SEC. 56, RANCHO DEL PASO
Assessor's Map Bk.283-Pg. 35
County of Sacramento, Calif.
Shelfield Estates Unit No. 3, R.M. Bk.58, Pg.23
NOTE—Assessor's Block Numbers Shown in Ellipses.
Assessor's Parcel Numbers Shown in Circles
100'
SHELFIELD DR.
CARMELO
COURT
LAMBETH
WAY
RETREAT WAY
BENTLEY
Bk.289
351
352
353
354
355
20
26
33
34
41
TOTAL LF PIPE
TOTAL NO. M. H.
TOTAL NO. SERVICE CONN.
TOTAL NO. F. B.
2188
10
39
2
93
94
95
96
97
98
99
100
101
102
103
104
105
106
107
108
109
110
111
112
113
114
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116
117
118
119
120
121
122
123
124
125
126
127
128
129
130
131
132
133
134

Fig. 12.4 Block map

Scale: 1′ = 100′ before reduction

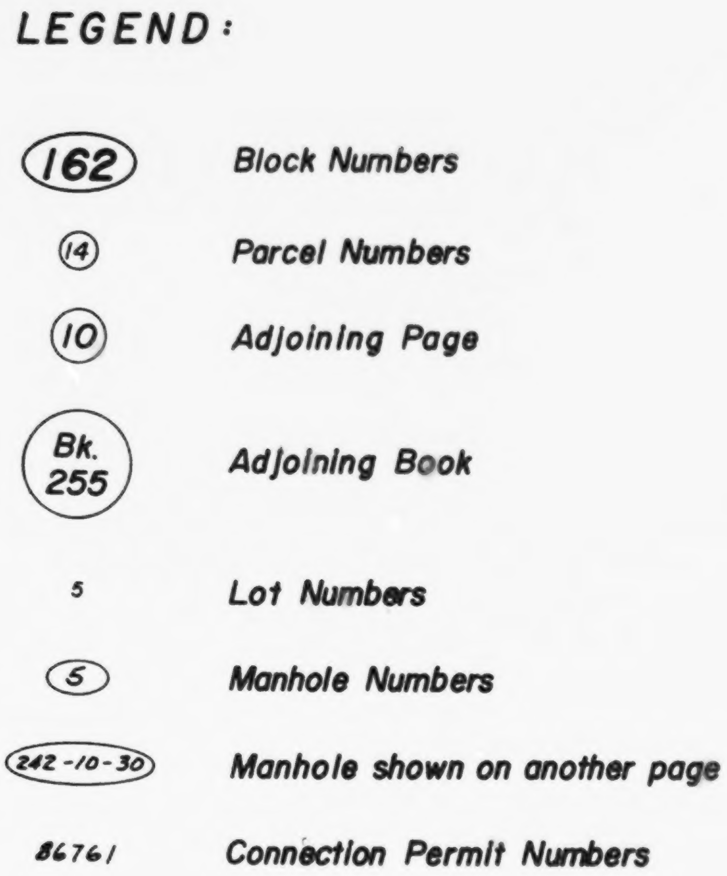
LEGEND:
162 Block Numbers
14 Parcel Numbers
10 Adjoining Page
Bk. 255 Adjoining Book
5 Lot Numbers
5 Manhole Numbers
242-10-30 Manhole shown on another page
86761 Connection Permit Numbers

Fig. 12.5 Block map numbering legend

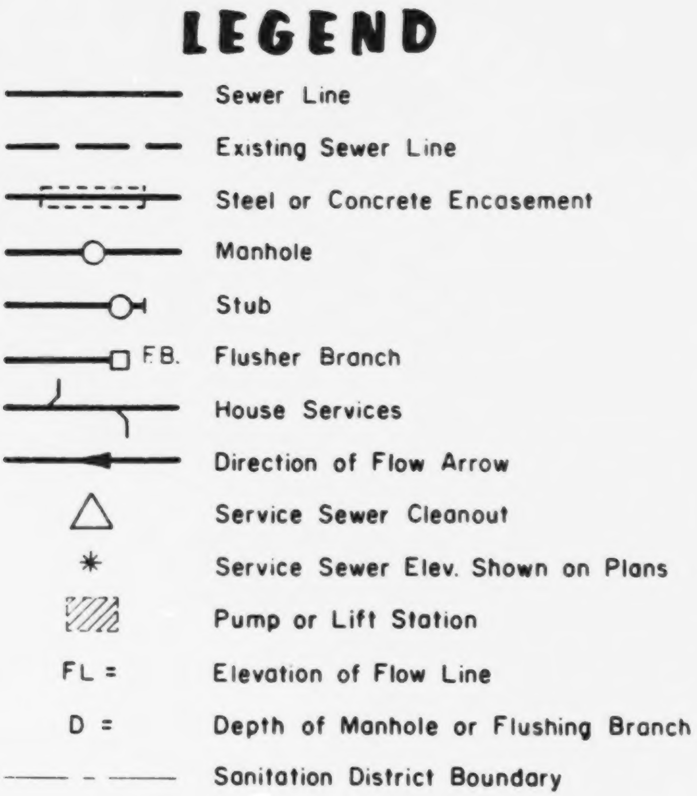
LEGEND
Sewer Line
Existing Sewer Line
Steel or Concrete Encasement
Manhole
Stub
F.B.
Flusher Branch
House Services
Direction of Flow Arrow
Service Sewer Cleanout
Service Sewer Elev. Shown on Plans
Pump or Lift Station
FL =
Elevation of Flow Line
D =
Depth of Manhole or Flushing Branch
Sanitation District Boundary

Fig. 12.6 Block map symbols

CHANGES IN COLLECTION SYSTEM

When new sections of sewer, manholes or other structures are built and placed in service, update maps to show new facilities. If sewers or structures settle, slip sideways or tilt, they are usually repaired and restored to their original conditions and locations. During repairs, record any changes you make to improve facility operation better or to stabilize an installation.

ANNUALLY

Updated maps should be printed at least once a year. Reprinting more often than annually would probably not be economically feasible. However, the process of gathering information needed for the annual reprinting should be a continuous one and conducted throughout the year as suggested below.

RECORDING CHANGES

- With tracings. When tracings are immediately available, changes should be recorded on the tracings as soon as they occur throughout the year.
- Without tracings. A suitable method of recording and filing changes as they occur should be implemented throughout the year. One method is to note the changes on the appropriate map page and file for recovery when needed. Changes on the tracings can then be made when the time comes for updating and printing of maps.

MAPPING PERSONNEL

A mapping system of any significant size will require trained personnel who are directly responsible for keeping maps current and accurate. You will need to establish a definite system for funneling map change information to the mapping personnel. Skilled drafting personnel are essential and management must make sure that all changes are recorded as soon as possible on the maps.

FIELD PERSONNEL

Even in the most efficient map updating programs, some changes will be overlooked or go unreported. This happens primarily because of the many details to be covered and the vast number of people involved. Field personnel can help in the following ways:

- Collection system operators. As the primary users and chief benefactors of a good mapping system, maintenance operators can be easily trained to report any discrepancy they encounter or changes they make in their daily activities. Supervisors should develop a specific system, with appropriate forms, to insure these reported discrepancies or changes are promptly forwarded to the mapping section.
- Construction inspectors. During construction of collection system facilities, changes may be made in existing facilities or discrepancies found. Inspectors should be instruct-

ed and required to note such information on their "as-built" plans. This information is used for future updating of maps.

FIELD CHECKING.

If you cannot have a formal system or set schedule for updating maps, periodic field checking may be practical. Properly trained field service request crews can accomplish this on a fill-in basis during periods with few service requests. Field checking is especially beneficial in smaller collection systems.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 399.

12.6F Which type of map contains the most details regarding a wastewater collection system?

12.6G Why should maps be updated?

12.6H How can maps be kept up-to-date?

12.67 Microfiche Copies

A superintendent of a wastewater collection system may want to consider the use of the microfiche technique for making copies of collection system maps more widely available for office and field use. Using this technique, maps are photographed and reproduced on film in micro size; many block maps are grouped in a logical manner on a 3 by 5- inch card. Any part of the mapping system can be used by placing the appropriate card in a microfiche viewer which illuminates the transparent fiche and magnifies the print to a readable size. Different types of viewers are powered by sunlight, batteries, 110-volt electrical systems or the electrical system of a vehicle.

The advantages of microfiche copies of maps include a low reproduction cost, ease of handling, less storage space and they do not deteriorate with repeated handling. On the other hand, the maps may be difficult to read under adverse conditions, referring from one map page to an adjoining page for information can be awkward, and changes to be made cannot be noted directly on a map.

12.68 Maps as Maintenance Records

In some instances maps provide an excellent method of recording maintenance activities.

SMALL COLLECTION SYSTEMS

Sufficient personnel may not be available to sustain an elaborate recordkeeping system. A separate set of maps kept in the office for record purposes only, can be useful in recording the following:

- Problem areas. Color codes can be used to designate specific problems such as roots or grease.
- Maintenance activities. Dates, type of maintenance performed, areas involved and production footages can be easily recorded on these maps.
- Pins can be used to indicate repeated problems in specific areas.
- Schedules. Proposed maintenance schedules, including due dates, can be indicated for specific areas through the use of flags.

MEDIUM-SIZED COLLECTION SYSTEMS

Again, sufficient personnel may not be available to sustain detailed card record systems. A combination of card files and maps for records may be effective. Information adaptable for recording on maps might include:

- Area-wide maintenance. Maintenance activities conducted on an area-wide basis can easily be recorded on maps through the use of color codes.
- Concentration of problems. Using colored pins to mark trouble spots, maps will show at a glance if problems are concentrated in one or more specific areas.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 399.

12.6I What are the advantages of using microfiche copies?

12.6J How can maps be used as a maintenance record?

12.6K How can problem areas be shown on a map?

DISCUSSION AND REVIEW QUESTIONS

Chapter 12. ADMINISTRATION

(Lesson 5 of 7 Lessons)

Write the answers to these questions in your notebook before continuing. The question numbering continues from Lesson 4.

24. Why are good maps needed for wastewater collection systems?
25. What information must be included on wastewater collection system maps?
26. Discuss the advantages of identifying the location of important points of underground utilities on a grid coordinate system.
27. Why do utility agencies use different types of maps (master, section and block maps)?
28. What can happen if maps are not kept up to date?

CHAPTER 12. ADMINISTRATION

(Lesson 6 of 7 Lessons)

12.7 MANAGEMENT INFORMATION SYSTEMS

Chapter 3, "Information Systems," of the *MANAGEMENT OF LOCAL PUBLIC WORKS*[4], published by the International City Management Association, provides an excellent introduction to management information systems that could be used by the superintendent of a wastewater collection system.

12.71 Need

A management information system meets several needs. The most common are:

- Simplification and improvement of work planning and scheduling, including the integration of recurring and on-demand jobs,
- Measurement and tracking of workforce productivity, and
- Development of unit costs and measurement of the impact of resource allocation to various activities.

A collection system's superintendent and staff need precise and accurate information at the right time for taking effective action and making sound decisions concerning the operation and maintenance of the collection system. Decisions based on inaccurate or insufficient information may cause inappropriate actions, confusion, and reduce operator morale.

12.72 Definition

A management information system is illustrated in Figure 12.7. Collection system operators, following directives issued by superintendents and supervisors, perform operational and maintenance work on the collection system and prepare work reports. Work reports are then assembled into records by staff personnel and become the data base for the information system. Records no longer needed for current information are removed from the data base and stored in archives in case they may be needed in the future. Work performed by contract, although not shown as a part of the system, generates work reports that are also assembled into records and become a part of the data base.

The data base is used to produce planning and controlling reports by staff personnel in the form requested by management. Management uses these reports for their work including planning for and deciding how and when to operate and maintain a collection system. Collection system operators are informed of management's plans and decisions by the issuance of directives to them, thus completing the circular flow of information between management and collection system operators.

Informal two-way communication of information across organizational lines, on both an interpersonal and group basis, between collection system operators and management should be encouraged by a superintendent. This type of information transfer is shown on Figure 12.7 as lines of direct communications between operators and management.

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[4] *MANAGEMENT OF LOCAL PUBLIC WORKS. Available from International City Management Association, 1120 G Street, NW, Washington, D.C. 2005. Price, $37.95.*

Data processing takes pieces of information independent in nature and unlimited in number (usually in the form of records) and produces useful information by arranging it into meaningful knowledge.

Key factors involved in the development of an effective management information system include:

1. Work reports must be complete in order to have all the data necessary to prepare all the information that may be needed for an intelligent decision.
2. Reports and records must be relevant to the objectives of management or valuable time will be wasted in preparing useless reports and processing data.
3. Planning and controlling reports must be concise to facilitate a proper decision.
4. All aspects of the system must be performed in a timely manner in order for information to be available when a decision must be made.

12.73 Data Processing with Microcomputers

The moderate cost of microcomputers and customized software make these systems available to most wastewater collection system agencies. Therefore, the superintendent of a collection system should, in most situations, be using microcomputers to facilitate an effective management information system.

12.731 How a Computer Works

Computers use microelectronic technology to store and arrange a massive amount of data at a very rapid rate to produce useful information as directed by computer programs called software. The quality of the information produced by computers is entirely dependent on the quality of data put into the computer and the software directing its processing. Information produced by a computer can either be read from a video screen or a hard (paper) copy is produced by a printer.

12.732 Computer Applications

A microcomputer and its software can be applied to a management information system in the following manner:

- Work reports prepared by collection system operators are used by staff personnel to gather data that is entered into the computer's memory to create a data base using data base management software. Entries are made using instructions appearing on a video screen and a typewriter keyboard.
- On requests entered into the computer by management or staff (using instructions provided by a combination of data management, spreadsheet and word processing software), the computer either displays the desired information reports on the video screen or produces a report in printed form. It is also possible to view information on the video screen and then decide if it should be printed.
- A microcomputer system can also be used to produce printed directives to operators in the same manner information reports are produced.

The operation and maintenance of some collection systems have been and are still being managed in an effective manner without the assistance of a microcomputer system and many of the records and reports illustrated later on in this chapter can be produced manually. However, a microcomputer system can store data, process it, and produce information at a more rapid rate and, due to the amount of data to be stored and processed, some of the illustrated information cannot practically be produced manually. A microcomputer simply provides a collection system superintendent with an additional tool for the more efficient management of a system.

12.733 Specialty Software

Several software programs have been designed specifically to assist agency staff personnel in the management of wastewater collection systems. These programs are produced (and copyrighted) by consulting engineering firms and software companies. The programs can be purchased from these firms and companies and they will assist a user in the installation and maintenance of their computer programs. Information on this type of computer software can be obtained from MICROCOMPUTERS IN PUBLIC WORKS, published by the American Public Works Association, 1313 E 60th Street, Chicago, Illinois 60637, price $60.00 to members and $75.00 to others.

A software package produced by Hansen Software, Inc., 1745 Markston Road, Sacramento, CA 95825, can be used to control and track the maintenance of main line segments, manholes and building service lines. The program provides the following capabilities:

- Inventory of main line segments and their specifications.
- Preventive maintenance scheduling on main lines either by individual lines or by geographic area.
- History of maintenance activities performed on main lines, service lines, and areas.
- Recording and tracking main line stoppages by date, main line segment, or service line ID.
- Recording and retrieval of information obtained from TV history reports.
- Cross reference of service lines by street address, main line segment, or service line ID.
- Reports on scheduled, unscheduled, and projected work orders, plus service line, area, and main line stoppages, and TV histories of sewer inspections, and
- Work orders generated for preventive and unscheduled maintenance activities.

The above programs can be supplemented with a Cost Management Module which provides detailed information on

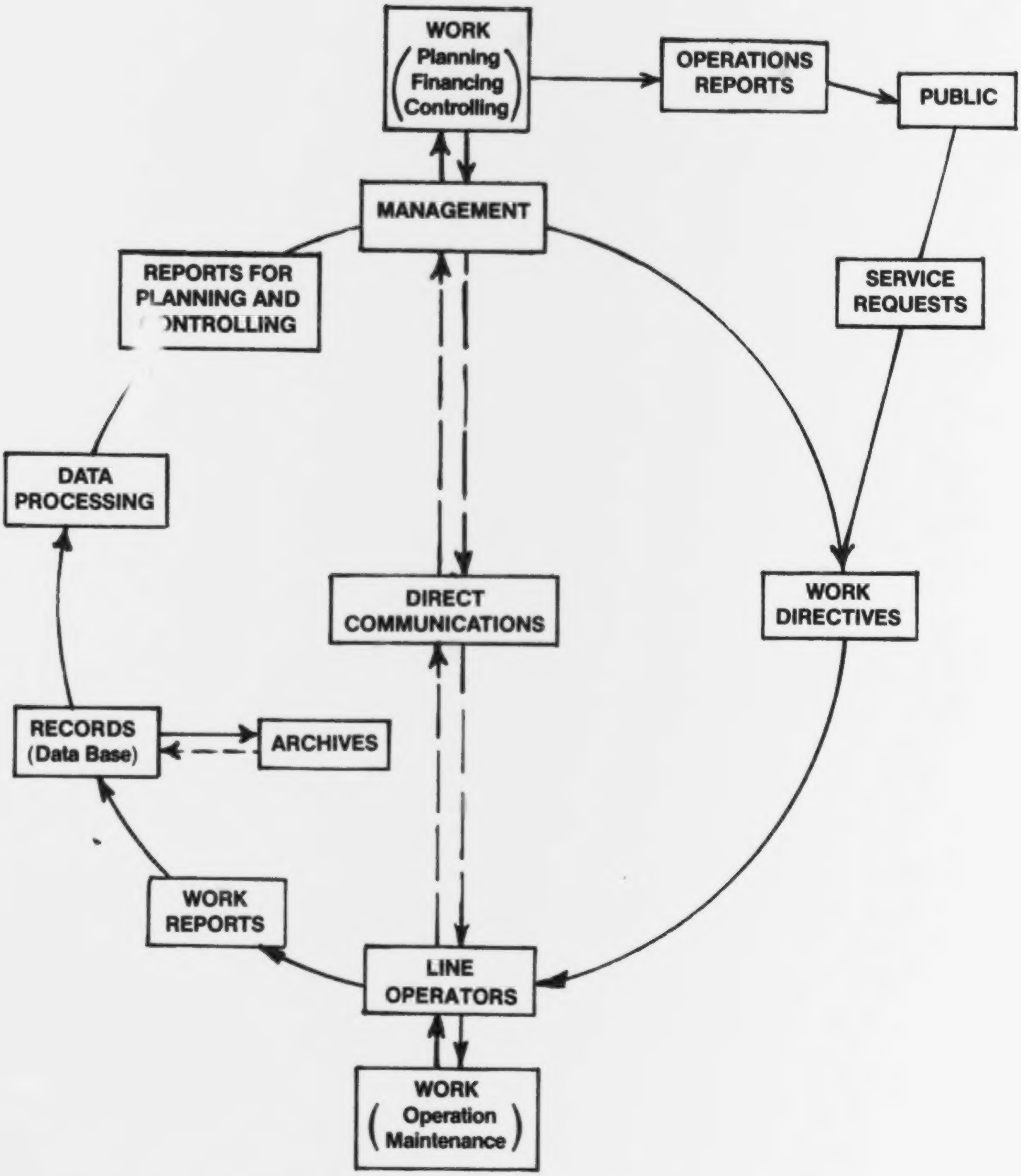

WORK
(Planning
Financing
Controlling)
OPERATIONS REPORTS
PUBLIC
MANAGEMENT
SERVICE REQUESTS
REPORTS FOR PLANNING AND CONTROLLING
DATA PROCESSING
DIRECT COMMUNICATIONS
WORK DIRECTIVES
RECORDS (Data Base)
ARCHIVES
WORK REPORTS
LINE OPERATORS
WORK
(Operation
Maintenance)

Fig. 12.7 Management information system

labor, equipment, and material costs associated with main line, area, and service line work orders.

The wastewater collection management system programs produced by Hansen, Inc., are used as an example of the computer programs being produced by engineering firms and software companies. This description is not intended to be an endorsement of the product.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 400.

12.7A What happens to current information no longer needed in a data base?

12.7B What does data processing do with information?

12.7C The quality of information produced by computers depends on what factors?

12.7D What kinds of reports can be generated by computer software programs?

12.74 Work Reports

Collection system operators performing work activities account for these activities by making daily work reports. Operators use forms prepared by management in order to produce the data relevant to the agency's management information system.

12.741 Need for Work Reports

Work reports are needed to develop data bases, or records, that are processed to produce the following planning and controlling report categories used by management:

- Payroll,
- Production,
- Work costs,
- System inventory,
- Main line maintenance history,
- Service line maintenance history, and
- Main and service line repair history.

12.742 Types of Work Reports

The types of work reports will vary with the type of management information system used by a collection system agency. However, report forms should be designed to provide the data essential for the production of planning and controlling reports previously described since they are needed for the efficient management of the collection system.

The following work report forms are the types used by a large collection system agency that uses microcomputers for data processing:

MAIN SEWER CONSTRUCTION

The form, *MAIN SEWER CONSTRUCTION DATA*, Figure 12.8, is used by a construction crew leader when working on main line construction and an inspector when the construction is performed by a contractor. Most of the requirements for information are self-explanatory. A crew leader initials the "Coded By" space and the clerk entering the data into a computer initials the "Entered By" space. The construction data is inserted in code form using the table of codes printed on the bottom of the form. This code designation will usually be the same code used for entering the data into a computer. The reverse side of the form, Figure 12.9, when completed by the crew leader, provides all the data needed to compute and report the cost of each construction project.

MAIN SEWER MAINTENANCE

The leader of a main sewer maintenance crew reports the daily work activities of the crew using the *MAIN SEWER MAINTENANCE DATA* form, Figure 12.10. This form is similar to the main sewer construction form. Note the information columns entitled "Overall Severity" and "Condition & Severity" and the codes for "Debris: Severity" to be used in the first column and the codes for "Sewer Severity" to be used in the second column. This information is subsequently used by a superintendent or supervisor to prioritize and schedule future maintenance and repair of main sewers.

The time, material, and equipment reporting form shown in Figure 12.9 is also printed on the reverse side of the main sewer maintenance form.

MAIN SEWER REPAIR

The leader of a crew making repairs on a main sewer reports this work using a *MAIN SEWER REPAIR DATA* form shown in Figure 12.11. To facilitate use of the form, it is made similar to the previous forms and uses similar coded entries. The time, material, and equipment report form, Figure 12.9, is also printed on the reverse side of this form.

STRUCTURE MAINTENANCE

Maintenance work performed on a collection system's manholes, cleanouts and special structures are reported by a crew leader using the *STRUCTURE - MAINTENANCE DATA* form shown in Figure 12.12. Note that this form is used to report entries into manholes, safety conditions and any odors that may require further investigation. The condition of a manhole frame and cover (F/C), barrel and cone (B/C), channel and steps are rated from "OK" to "Severe" to provide information for scheduling of future repairs. As with the previous report forms, the time, material and equipment reporting form is printed on the reverse side.

STRUCTURE REPAIR OR ABANDONMENT

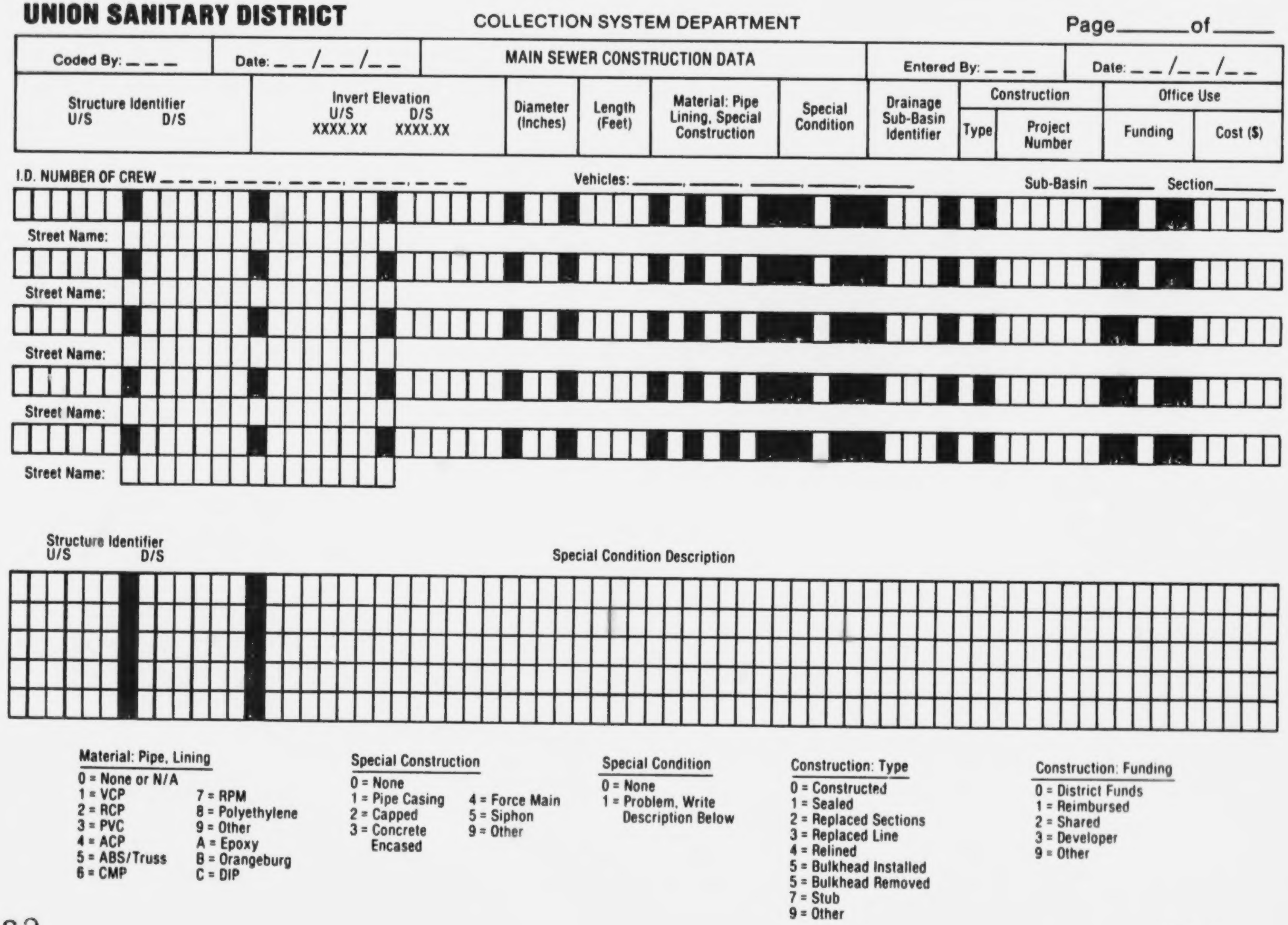
If a manhole, cleanout or special structure is repaired or abandoned, the leader of the crew performing the work reports the activity using the *STRUCTURE - REPAIR OR ABANDON DATA* form, Figure 12.13. Note how the use of codes allows a great amount of information to be reported on this one form. The time, material, and equipment report form is also on the reverse side of this form.

BUILDING SEWER MAINTENANCE

Building sewer maintenance work is reported by a crew leader using the *BUILDING SEWER - MAINTENANCE DATA, SERVICE REQUEST - OWNER PROBLEM* report form shown as Figure 12.14. Note the use of the debris and sewer severity reporting similar to reporting on main sewer maintenance. This information is again used for scheduling future maintenance and repair of building sewers. The reverse side of this form contains the standard time, material and equipment report form.

BUILDING SEWER REPAIR

The final form in the series of work reports developed by the collection agency is used by a crew leader to report building sewer repair work and is entitled *BUILDING SEWER - REPAIR DATA*, Figure 12.15. The report form, as with the others in the series, allows a great amount of data to be



UNION SANITARY DISTRICT COLLECTION SYSTEM DEPARTMENT Page______of_____

Coded By: _ _ _	Date: _ _ /_ _ /_ _	MAIN SEWER CONSTRUCTION DATA	Entered By: _ _ _	Date: _ _ /_ _ /_ _

Structure Identifier U/S D/S	Invert Elevation U/S D/S XXXX.XX XXXX.XX	Diameter (Inches)	Length (Feet)	Material: Pipe Lining, Special Construction	Special Condition	Drainage Sub-Basin Identifier	Construction		Office Use	
							Type	Project Number	Funding	Cost ($)

I.D. NUMBER OF CREW _ _ _, _ _ _, _ _ _, _ _ _, _ _ _ Vehicles: ______, ______, ______, ______, ______ Sub-Basin _______ Section_______

Street Name:

Street Name:

Street Name:

Street Name:

Street Name:

Structure Identifier
U/S D/S

Special Condition Description

Material: Pipe, Lining
0 = None or N/A
1 = VCP
2 = RCP
3 = PVC
4 = ACP
5 = ABS/Truss
6 = CMP
7 = RPM
8 = Polyethylene
9 = Other
A = Epoxy
B = Orangeburg
C = DIP

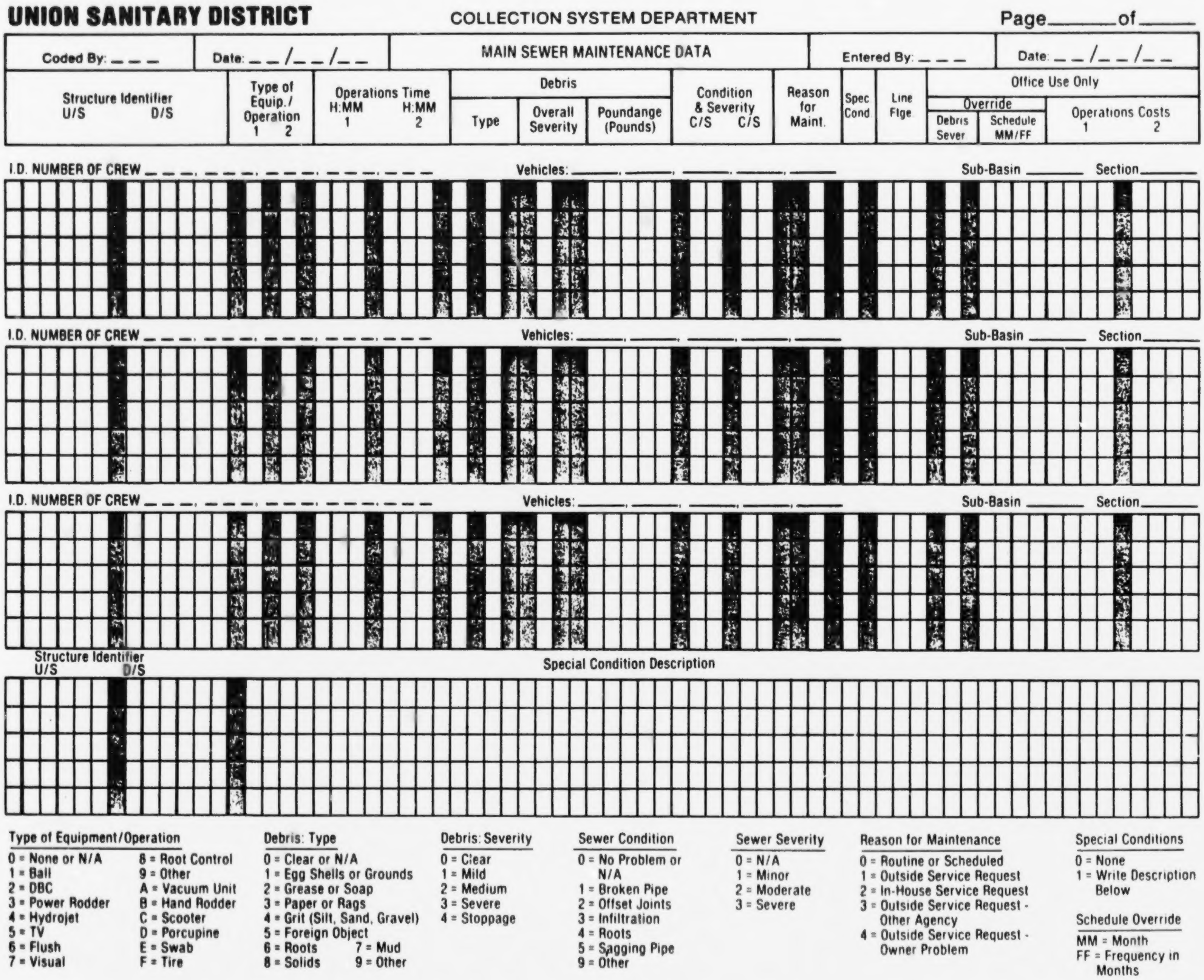
Special Construction
0 = None
1 = Pipe Casing
2 = Capped
3 = Concrete Encased
4 = Force Main
5 = Siphon
9 = Other

Special Condition
0 = None
1 = Problem, Write Description Below

Construction: Type
0 = Constructed
1 = Sealed
2 = Replaced Sections
3 = Replaced Line
4 = Relined
5 = Bulkhead Installed
5 = Bulkhead Removed
7 = Stub
9 = Other

Construction: Funding
0 = District Funds
1 = Reimbursed
2 = Shared
3 = Developer
9 = Other

Fig. 12.8 Main sewer construction report



UNION SANITARY DISTRICT COLLECTION SYSTEM DEPARTMENT Page______of_____

Coded By: _ _ _	Date: _ _/_ _/_ _	MAIN SEWER MAINTENANCE DATA	Entered By: _ _ _	Date: _ _/_ _/_ _

Structure Identifier U/S D/S	Type of Equip./ Operation 1 2	Operations Time H:MM 1 H:MM 2	Debris			Condition & Severity C/S C/S	Reason for Maint.	Spec Cond	Line Ftge	Office Use Only		
										Override		
			Type	Overall Severity	Poundange (Pounds)					Debris Sever	Schedule MM/FF	Operations Costs 1 2

I.D. NUMBER OF CREW _ _ _, _ _ _, _ _ _, _ _ _, _ _ _ Vehicles: _____, _____, _____, _____, _____ Sub-Basin _____ Section_____

I.D. NUMBER OF CREW _ _ _, _ _ _, _ _ _, _ _ _, _ _ _ Vehicles: _____, _____, _____, _____, _____ Sub-Basin _____ Section_____

I.D. NUMBER OF CREW _ _ _, _ _ _, _ _ _, _ _ _, _ _ _ Vehicles: _____, _____, _____, _____, _____ Sub-Basin _____ Section_____

Structure Identifier
U/S D/S

Special Condition Description

Type of Equipment/Operation

- 0 = None or N/A
- 1 = Ball
- 2 = DBC
- 3 = Power Rodder
- 4 = Hydrojet
- 5 = TV
- 6 = Flush
- 7 = Visual
- 8 = Root Control
- 9 = Other
- A = Vacuum Unit
- B = Hand Rodder
- C = Scooter
- D = Porcupine
- E = Swab
- F = Tire

Debris: Type

- 0 = Clear or N/A
- 1 = Egg Shells or Grounds
- 2 = Grease or Soap
- 3 = Paper or Rags
- 4 = Grit (Silt, Sand, Gravel)
- 5 = Foreign Object
- 6 = Roots
- 7 = Mud
- 8 = Solids
- 9 = Other

Debris: Severity

- 0 = Clear
- 1 = Mild
- 2 = Medium
- 3 = Severe
- 4 = Stoppage

Sewer Condition

- 0 = No Problem or N/A
- 1 = Broken Pipe
- 2 = Offset Joints
- 3 = Infiltration
- 4 = Roots
- 5 = Sagging Pipe
- 9 = Other

Sewer Severity

- 0 = N/A
- 1 = Minor
- 2 = Moderate
- 3 = Severe

Reason for Maintenance

- 0 = Routine or Scheduled
- 1 = Outside Service Request
- 2 = In-House Service Request
- 3 = Outside Service Request - Other Agency
- 4 = Outside Service Request - Owner Problem

Special Conditions

- 0 = None
- 1 = Write Description Below

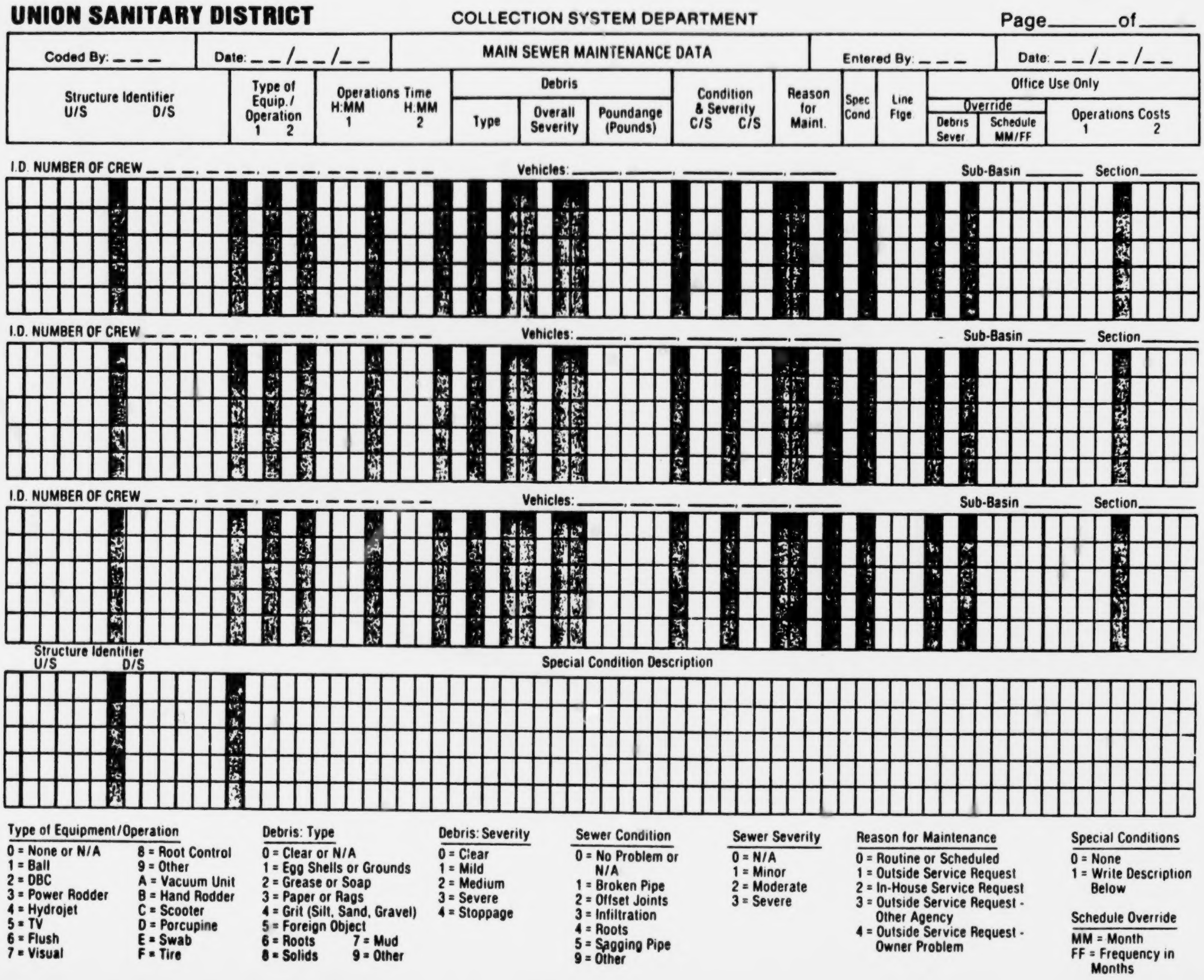
Schedule Override

- MM = Month
- FF = Frequency in Months

Fig. 12.9 Time, material, and equipment report

401

402



UNION SANITARY DISTRICT COLLECTION SYSTEM DEPARTMENT Page______of_____

Coded By: _ _ _	Date: _ _/_ _/_ _	MAIN SEWER MAINTENANCE DATA	Entered By: _ _ _	Date: _ _/_ _/_ _

Structure Identifier U/S D/S	Type of Equip./Operation 1 2	Operations Time H:MM 1 H:MM 2	Debris			Condition & Severity C/S C/S	Reason for Maint.	Spec Cond	Line Ftge	Office Use Only		
										Override		
			Type	Overall Severity	Poundange (Pounds)					Debris Sever	Schedule MM/FF	Operations Costs 1 2

I.D. NUMBER OF CREW _ _ _, _ _ _, _ _ _, _ _ _, _ _ _ Vehicles: _____, _____, _____, _____, _____ Sub-Basin ______ Section______

I.D. NUMBER OF CREW _ _ _, _ _ _, _ _ _, _ _ _, _ _ _ Vehicles: _____, _____, _____, _____, _____ Sub-Basin ______ Section______

I.D. NUMBER OF CREW _ _ _, _ _ _, _ _ _, _ _ _, _ _ _ Vehicles: _____, _____, _____, _____, _____ Sub-Basin ______ Section______

Structure Identifier U/S D/S Special Condition Description

Type of Equipment/Operation

0 = None or N/A
1 = Ball
2 = DBC
3 = Power Rodder
4 = Hydrojet
5 = TV
6 = Flush
7 = Visual
8 = Root Control
9 = Other
A = Vacuum Unit
B = Hand Rodder
C = Scooter
D = Porcupine
E = Swab
F = Tire

Debris: Type

0 = Clear or N/A
1 = Egg Shells or Grounds
2 = Grease or Soap
3 = Paper or Rags
4 = Grit (Silt, Sand, Gravel)
5 = Foreign Object
6 = Roots
7 = Mud
8 = Solids
9 = Other

Debris: Severity

0 = Clear
1 = Mild
2 = Medium
3 = Severe
4 = Stoppage

Sewer Condition

0 = No Problem or N/A
1 = Broken Pipe
2 = Offset Joints
3 = Infiltration
4 = Roots
5 = Sagging Pipe
9 = Other

Sewer Severity

0 = N/A
1 = Minor
2 = Moderate
3 = Severe

Reason for Maintenance

0 = Routine or Scheduled
1 = Outside Service Request
2 = In-House Service Request
3 = Outside Service Request - Other Agency
4 = Outside Service Request - Owner Problem

Special Conditions

0 = None
1 = Write Description Below

Schedule Override

MM = Month
FF = Frequency in Months

Fig. 12.10 Main sewer maintenance report

UNION SANITARY DISTRICT COLLECTION SYSTEM DEPARTMENT Page_____of_____

Coded By: _ _ _	Date: _ _/_ _/_ _	MAIN SEWER REPAIR DATA	Entered By: _ _ _	Date: _ _/_ _/_ _

Structure Identifier U/S D/S	Diameter (Inches)	Material: Pipe, Lining, Special Construction	Special Condition	Repair			Office Use Only		
				Type	Work Order Number		Complete	Funding	Cost ($)

I.D. NUMBER OF CREW _ _ _, _ _ _, _ _ _, _ _ _, _ _ _ Vehicles: _____, _____, _____, _____, _____ Sub-Basin _____ Section_____

I.D. NUMBER OF CREW _ _ _, _ _ _, _ _ _, _ _ _, _ _ _ Vehicles: _____, _____, _____, _____, _____ Sub-Basin _____ Section_____

Structure Identifier U/S D/S	Special Condition Description

Material: Pipe, Lining

0 = None or N/A
1 = VCP
2 = RCP
3 = PVC
4 = ACP
5 = ABS/Truss
6 = CMP
7 = RPM
8 = Polyethylene
9 = Other
A = Epoxy
B = Orangeburg
C = DIP

Material: Construction

0 = None
1 = Pipe Casing
2 = Capped
3 = Concrete Encased
4 = Force Main
5 = Siphon
9 = Other

Special Condition

0 = None
1 = Problem, Write Description Below

Repair: Type

0 = Constructed
1 = Sealed
2 = Replaced Sections
3 = Replaced Line
4 = Relined
5 = Bulkhead Installed
5 = Bulkhead Removed
7 = Stub
9 = PAVE or/ OTHER — (Use with Spec. Cond.)

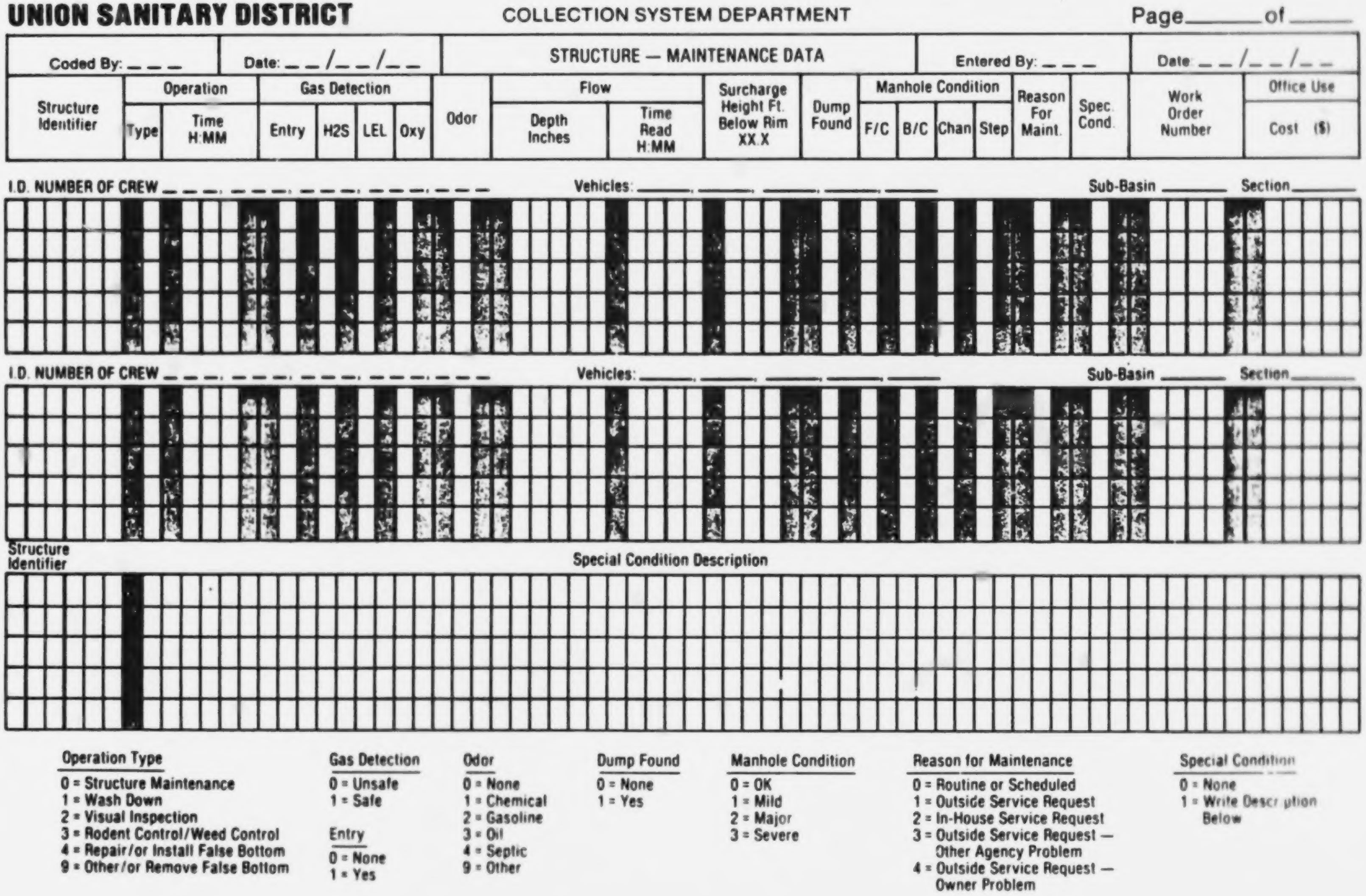
Complete

0 = No
1 = Yes

Funding

0 = District Funds
1 = Reimbursed
2 = Shared
3 = Developer
9 = Other

Fig. 12.11 Main sewer repair report



UNION SANITARY DISTRICT COLLECTION SYSTEM DEPARTMENT Page ____ of ____

Coded By: ___	Date: __/__/__	STRUCTURE — MAINTENANCE DATA	Entered By: ___	Date: __/__/__

Structure Identifier	Operation		Gas Detection				Odor	Flow		Surcharge Height Ft. Below Rim XX.X	Dump Found	Manhole Condition				Reason For Maint.	Spec. Cond.	Work Order Number	Office Use
	Type	Time H:MM	Entry	H2S	LEL	Oxy		Depth Inches	Time Read H:MM			F/C	B/C	Chan	Step				Cost ($)

I.D. NUMBER OF CREW ___, ___, ___, ___, ___ Vehicles: ____, ____, ____, ____, ____ Sub-Basin ____ Section ____

I.D. NUMBER OF CREW ___, ___, ___, ___, ___ Vehicles: ____, ____, ____, ____, ____ Sub-Basin ____ Section ____

Structure Identifier

Special Condition Description

Operation Type
- 0 = Structure Maintenance
- 1 = Wash Down
- 2 = Visual Inspection
- 3 = Rodent Control/Weed Control
- 4 = Repair/or Install False Bottom
- 9 = Other/or Remove False Bottom

Gas Detection
- 0 = Unsafe
- 1 = Safe

Entry
- 0 = None
- 1 = Yes

Odor
- 0 = None
- 1 = Chemical
- 2 = Gasoline
- 3 = Oil
- 4 = Septic
- 9 = Other

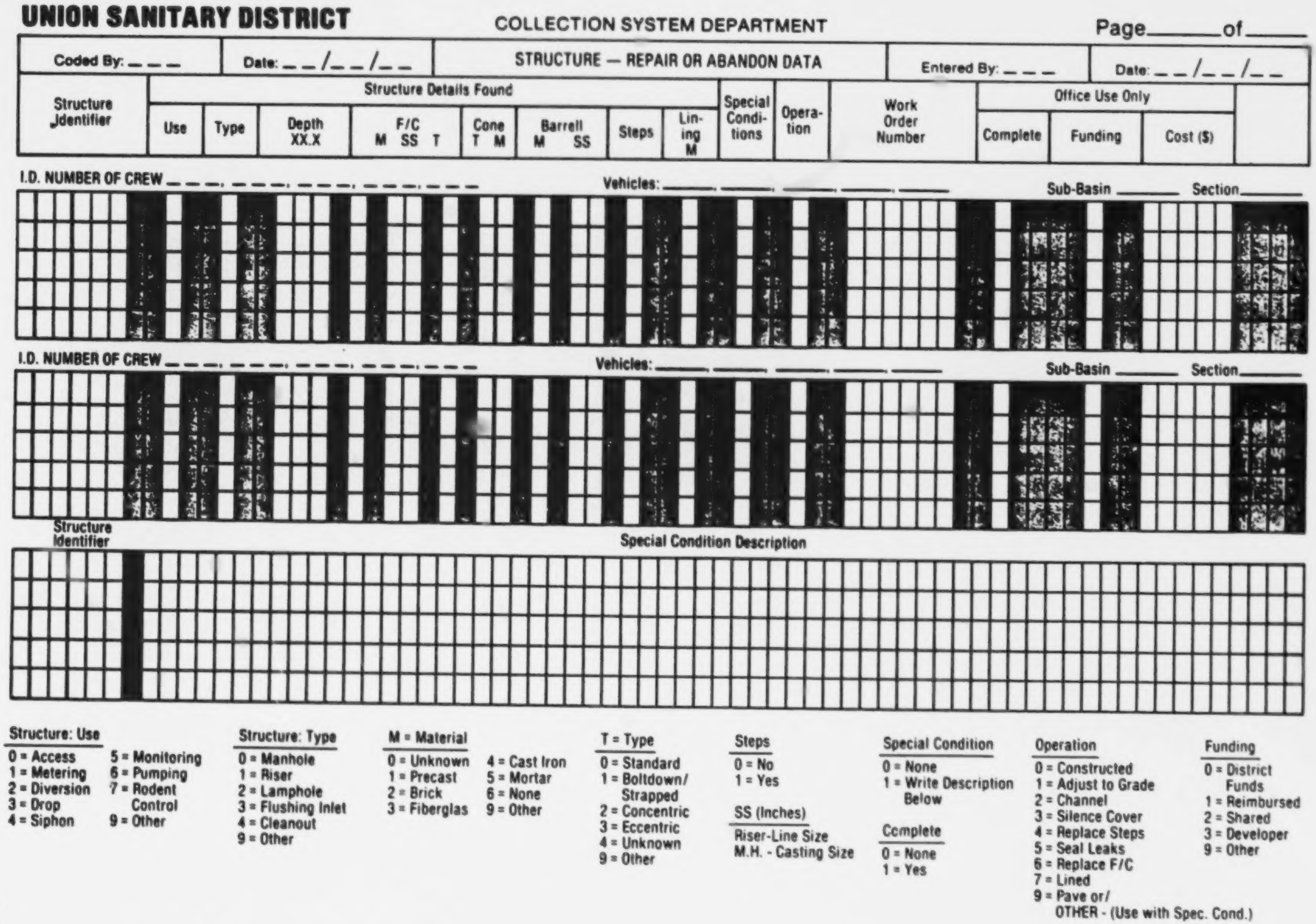
Dump Found
- 0 = None
- 1 = Yes

Manhole Condition
- 0 = OK
- 1 = Mild
- 2 = Major
- 3 = Severe

Reason for Maintenance
- 0 = Routine or Scheduled
- 1 = Outside Service Request
- 2 = In-House Service Request
- 3 = Outside Service Request — Other Agency Problem
- 4 = Outside Service Request — Owner Problem

Special Condition
- 0 = None
- 1 = Write Description Below

Fig. 12.12 Structure maintenance report



UNION SANITARY DISTRICT COLLECTION SYSTEM DEPARTMENT Page_____of_____

Coded By: _ _ _	Date: _ _/_ _/_ _	STRUCTURE — REPAIR OR ABANDON DATA	Entered By: _ _ _	Date: _ _/_ _/_ _

Structure Identifier	Structure Details Found								Special Conditions	Operation	Work Order Number	Office Use Only			
	Use	Type	Depth XX.X	F/C M SS T	Cone T M	Barrell M SS	Steps	Lining M				Complete	Funding	Cost ($)	

I.D. NUMBER OF CREW _ _ _, _ _ _, _ _ _, _ _ _, _ _ _ Vehicles: _____, _____, _____, _____, _____ Sub-Basin _____ Section_____

I.D. NUMBER OF CREW _ _ _, _ _ _, _ _ _, _ _ _, _ _ _ Vehicles: _____, _____, _____, _____, _____ Sub-Basin _____ Section_____

Structure Identifier

Special Condition Description

Structure: Use
0 = Access
1 = Metering
2 = Diversion
3 = Drop
4 = Siphon
5 = Monitoring
6 = Pumping
7 = Rodent Control
9 = Other

Structure: Type
0 = Manhole
1 = Riser
2 = Lamphole
3 = Flushing Inlet
4 = Cleanout
9 = Other

M = Material
0 = Unknown
1 = Precast
2 = Brick
3 = Fiberglas
4 = Cast Iron
5 = Mortar
6 = None
9 = Other

T = Type
0 = Standard
1 = Boltdown/Strapped
2 = Concentric
3 = Eccentric
4 = Unknown
9 = Other

Steps
0 = No
1 = Yes

SS (Inches)
Riser-Line Size
M.H. - Casting Size

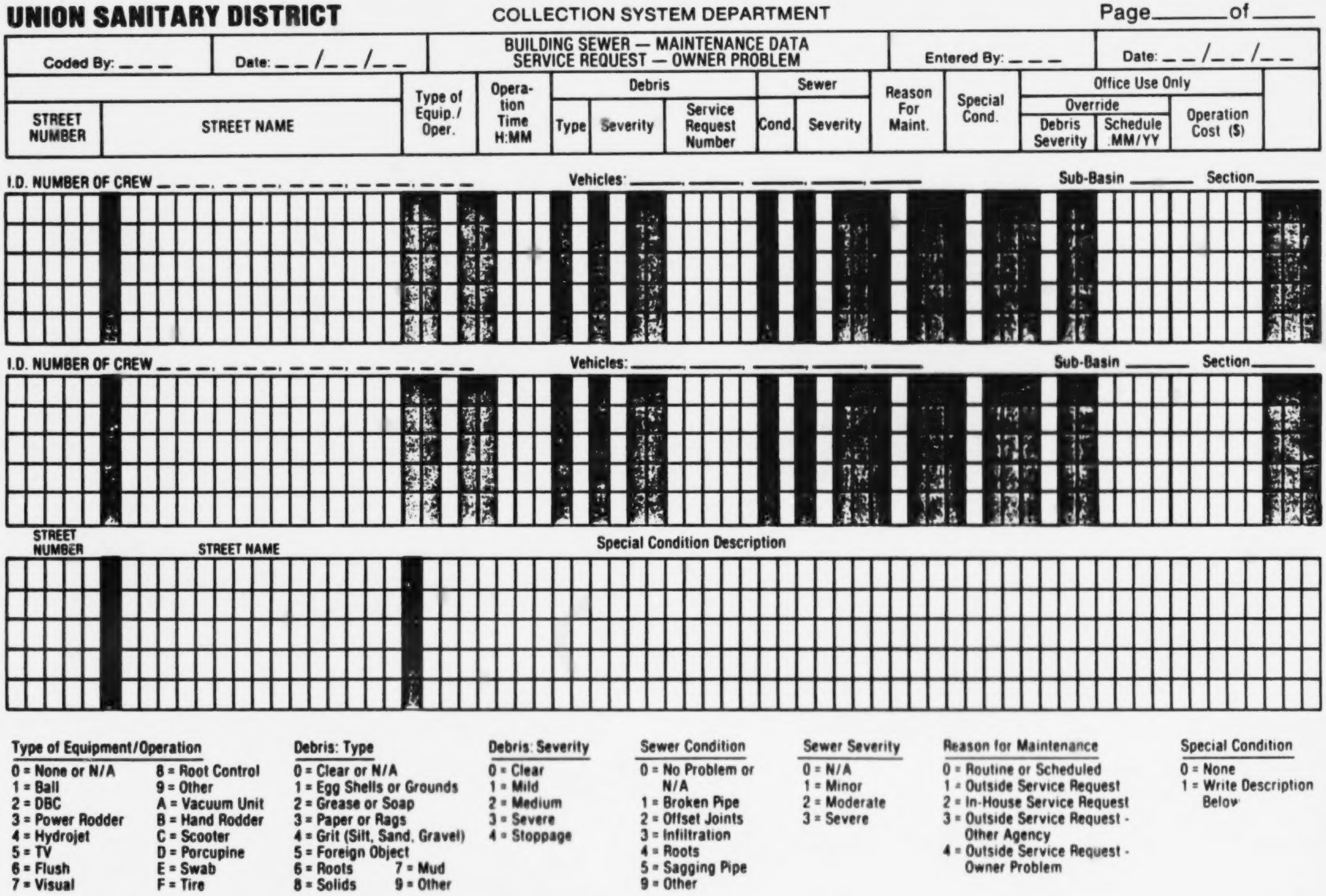
Special Condition
0 = None
1 = Write Description Below

Complete
0 = None
1 = Yes

Operation
0 = Constructed
1 = Adjust to Grade
2 = Channel
3 = Silence Cover
4 = Replace Steps
5 = Seal Leaks
6 = Replace F/C
7 = Lined
9 = Pave or/ OTHER - (Use with Spec. Cond.)

Funding
0 = District Funds
1 = Reimbursed
2 = Shared
3 = Developer
9 = Other

Fig. 12.13 Structure repair or abandonment report



UNION SANITARY DISTRICT COLLECTION SYSTEM DEPARTMENT Page______of_____

Coded By: _ _ _	Date: _ _/_ _/_ _	BUILDING SEWER — MAINTENANCE DATA SERVICE REQUEST — OWNER PROBLEM	Entered By: _ _ _	Date: _ _/_ _/_ _

STREET NUMBER	STREET NAME	Type of Equip./Oper.	Operation Time H:MM	Debris			Sewer		Reason For Maint.	Special Cond.	Office Use Only		
											Override		
				Type	Severity	Service Request Number	Cond.	Severity			Debris Severity	Schedule MM/YY	Operation Cost ($)

I.D. NUMBER OF CREW _ _ _, _ _ _, _ _ _, _ _ _, _ _ _ Vehicles: _____, _____, _____, _____, _____ Sub-Basin ______ Section______

I.D. NUMBER OF CREW _ _ _, _ _ _, _ _ _, _ _ _, _ _ _ Vehicles: _____, _____, _____, _____, _____ Sub-Basin ______ Section______

STREET NUMBER STREET NAME Special Condition Description

Type of Equipment/Operation
- 0 = None or N/A
- 1 = Ball
- 2 = DBC
- 3 = Power Rodder
- 4 = Hydrojet
- 5 = TV
- 6 = Flush
- 7 = Visual
- 8 = Root Control
- 9 = Other
- A = Vacuum Unit
- B = Hand Rodder
- C = Scooter
- D = Porcupine
- E = Swab
- F = Tire

Debris: Type
- 0 = Clear or N/A
- 1 = Egg Shells or Grounds
- 2 = Grease or Soap
- 3 = Paper or Rags
- 4 = Grit (Silt, Sand, Gravel)
- 5 = Foreign Object
- 6 = Roots
- 7 = Mud
- 8 = Solids
- 9 = Other

Debris: Severity
- 0 = Clear
- 1 = Mild
- 2 = Medium
- 3 = Severe
- 4 = Stoppage

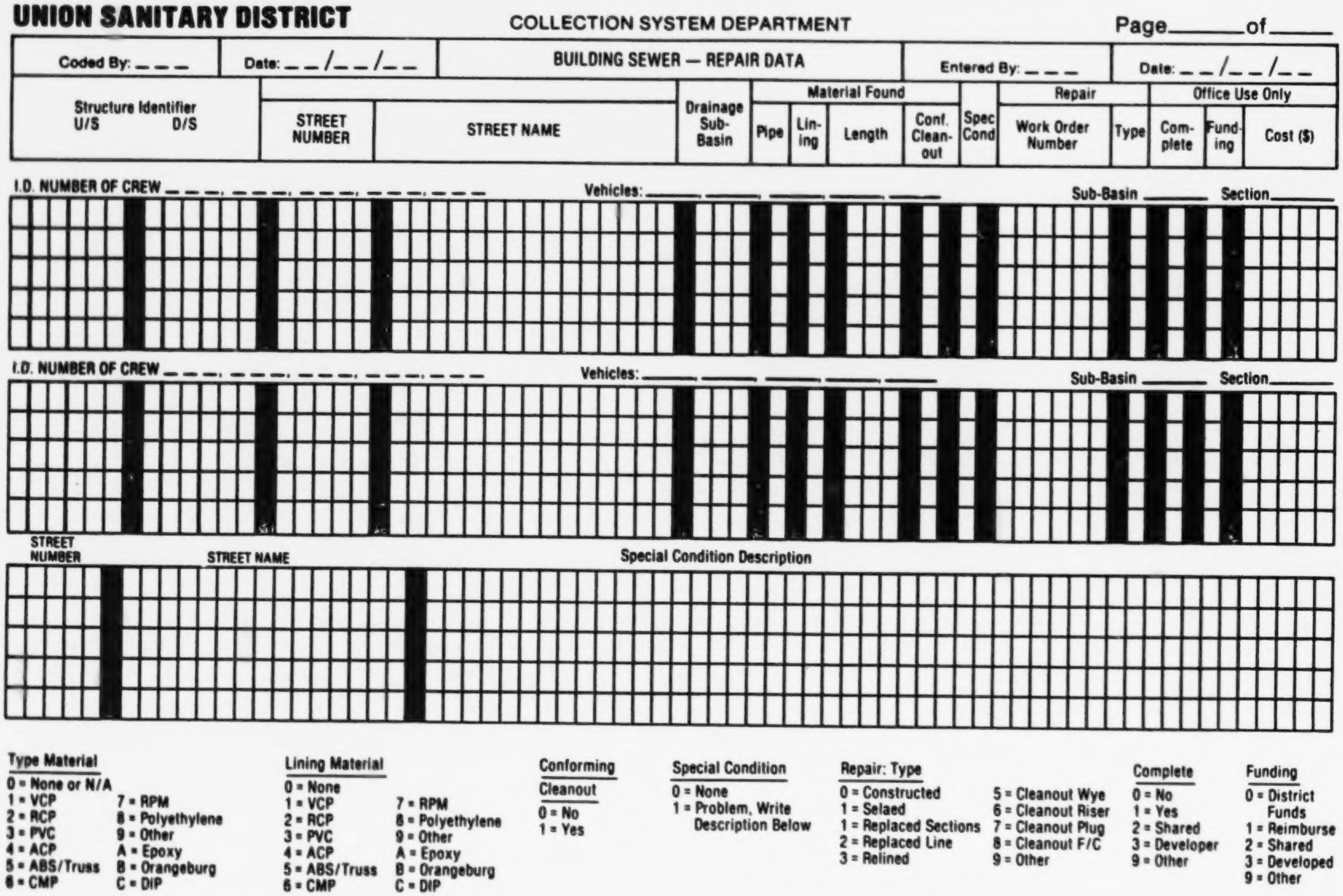
Sewer Condition
- 0 = No Problem or N/A
- 1 = Broken Pipe
- 2 = Offset Joints
- 3 = Infiltration
- 4 = Roots
- 5 = Sagging Pipe
- 9 = Other

Sewer Severity
- 0 = N/A
- 1 = Minor
- 2 = Moderate
- 3 = Severe

Reason for Maintenance
- 0 = Routine or Scheduled
- 1 = Outside Service Request
- 2 = In-House Service Request
- 3 = Outside Service Request - Other Agency
- 4 = Outside Service Request - Owner Problem

Special Condition
- 0 = None
- 1 = Write Description Below

Fig. 12.14 Building sewer maintenance, service request, and owner problem report



UNION SANITARY DISTRICT COLLECTION SYSTEM DEPARTMENT Page______of_____

Coded By: _ _ _	Date: _ _/_ _/_ _	BUILDING SEWER — REPAIR DATA	Entered By: _ _ _	Date: _ _/_ _/_ _

Structure Identifier U/S D/S	STREET NUMBER	STREET NAME	Drainage Sub-Basin	Material Found				Spec Cond	Repair		Office Use Only		
				Pipe	Lin-ing	Length	Conf. Clean-out		Work Order Number	Type	Com-plete	Fund-ing	Cost ($)

I.D. NUMBER OF CREW _ _ _, _ _ _, _ _ _, _ _ _, _ _ _ Vehicles: _____, _____, _____, _____, _____ Sub-Basin _____ Section_____

I.D. NUMBER OF CREW _ _ _, _ _ _, _ _ _, _ _ _, _ _ _ Vehicles: _____, _____, _____, _____, _____ Sub-Basin _____ Section_____

STREET NUMBER STREET NAME Special Condition Description

Type Material
0 = None or N/A
1 = VCP
2 = RCP
3 = PVC
4 = ACP
5 = ABS/Truss
6 = CMP
7 = RPM
8 = Polyethylene
9 = Other
A = Epoxy
B = Orangeburg
C = DIP

Lining Material
0 = None
1 = VCP
2 = RCP
3 = PVC
4 = ACP
5 = ABS/Truss
6 = CMP
7 = RPM
8 = Polyethylene
9 = Other
A = Epoxy
B = Orangeburg
C = DIP

Conforming Cleanout
0 = No
1 = Yes

Special Condition
0 = None
1 = Problem, Write Description Below

Repair: Type
0 = Constructed
1 = Selaed
1 = Replaced Sections
2 = Replaced Line
3 = Relined
5 = Cleanout Wye
6 = Cleanout Riser
7 = Cleanout Plug
8 = Cleanout F/C
9 = Other

Complete
0 = No
1 = Yes
2 = Shared
3 = Developer
9 = Other

Funding
0 = District Funds
1 = Reimburse
2 = Shared
3 = Developed
9 = Other

Fig. 12.15 Building sewer repair report

submitted by collection system operators for computer processing into information that is used by management to plan and direct the operation and maintenance of the agency's extensive wastewater collection system.

12.743 Retention of Reports

If all the information submitted on work reports is transferred to records, either in the form of computer-readable electronic disks or written material, the reports may be discarded.

If some of the information is not transferred to separate record documents, the work reports containing this information should be retained in a recoverable manner until it is apparent that the information is no longer useful.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 400.

12.7E How do collection system operators account for their daily work activities?

12.7F List the types of work reports used by collection system agencies.

12.7G Who would use a "main sewer construction data" form?

12.7H List the types of debris that can be found in sewers.

12.7I List the types of conditions that can be found in sewers.

12.75 Records

Records consist of written or electronically stored data that perpetuate a knowledge of events. From its start, management of a collection system will begin to generate records. The variety of records to be produced is unlimited. Size of the collection system, scope of activities, variety of programs, and the desires of supervisors and management, all will have an influence on the volume and detail of the records that are produced. Supervisors will find their personal involvement with actual recordkeeping will vary in relation to the size of their particular collection system.

The supervisor of a small collection system may be directly involved in the day-to-day recordkeeping activities of all aspects of the operation. In fact, the supervisor may be personally responsible for the preparation of many of the required records. In such a case, the supervisor will certainly take an active role in the deciding what types of records are needed and on what forms they are to be recorded.

The supervisor of a large collection system may encounter entirely different circumstances. Larger organizations will have more sophisticated record systems, with recordkeeping processes and policies that have been set up by specialized accounting sections. The supervisor may be responsible only for the administration of these processes and adherence to set policies.

Records pertinent to collection systems cover a wide range of needs and activities. Cost accounting, personnel, production, payroll, and history are just a few examples of major concerns. For the purpose of this section, we will place our emphasis on records that are of operational interest.

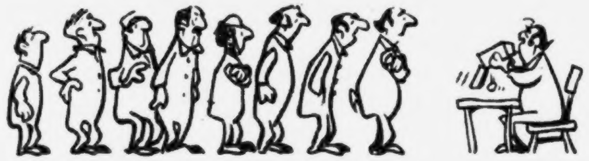
12.751 Need for Records

In general, records fill two basic needs. They record the past and provide a sound basis on which to plan the future. To meet these needs, records will have to be maintained on almost every activity and event that occurs in the daily operation and maintenance of the collection system. Some major areas of importance are discussed in this section.

PAYROLLS AND COST ACCOUNTING

Costs must be of prime concern to all maintenance supervisors. It is not enough that the supervisor maintain the system to a high degree of efficiency — the supervisor also is accountable for the costs involved.

- Labor. Time sheets, time cards, payrolls, time reporting, are all of vital importance to each of us. We all want to be paid. Every supervisor should be particularly attentive to the accuracy, completeness, and punctuality of time reporting. The supervisor, too, wants the operators paid accurately and on time. Delayed or inaccurate paychecks do little to improve employee morale.



- Equipment. As with labor costs, accurate reporting of daily use of equipment is also necessary.
- Supplies. Distribution, consumption, and use of materials must be accounted for accurately. Supplies usually are obtained from two sources, outside vendors and in-house stores. Special attention should be given to efficient handling of delivery receipts, bills and statements generated by purchases from outside vendors. Vendors also expect to be paid promptly and you can minimize carrying charges by doing so. Maintaining good relations with these vendors can come back as a direct benefit to you when an emergency occurs and you need a specialty item in a hurry.
- Services. Many maintenance organizations do not have the necessary equipment or adequate staff to complete all their required activities. Certain aspects of their work may require specialized equipment, or have an infrequent need factor. Such work might be more economically performed by other than in-house staff. From an operational standpoint, it is important to maintain close accounting of the cost of these outside services. A significant increase in volume might indicate that it would be more economical to acquire the necessary equipment and/or staff needed to perform such work in-house.

BASIS FOR PLANNING AND SCHEDULING

A maintenance schedule or program should be designed to alleviate or eliminate certain problem conditions that are known to exist within a collection system. Adequate records are required to locate and identify these conditions and provide information for planning and timely scheduling of maintenance procedures. The types of records and forms needed to provide this information are covered in detail in Section 12.752, "Types of Records."

BUDGETING

At budget time, material and equipment records become of prime importance to a supervisor. Accurate records detailing last year's activities, costs, work load, growth, and production are the best justification for next year's budget requests. Good records are essential for the preparation of a budget and programs to provide for an effective collection system operation and maintenance program. Use your records to document the fact that collection system programs are as important as the programs of other agency divisions with which you may be competing for funds.

- Staffing. Requests for increased staffing are one of the most difficult budget items to justify to the satisfaction of management. Rarely does management accept a request for more staff when the request is based solely on the opinion or experience of the supervisor, regardless of the supervisor's competency. Accurate records can provide the necessary justification for additional staff. Analysis and presentation of records covering several years can indicate a definite trend in your division's activities. They can verify that your division's work load has increased to a point that makes additional staffing essential and justified.

  Another possible approach you might take in the preparation and justification of budgets is to compare your division's programs with staffing guides developed by the U.S. Environmental Protection Agency and other responsible sources. Be sure to consider the unique aspects of your division when using the number of personnel used to accomplish similar collection system program requests.

- Equipment (additional and replacement). As with staffing, these items must also be justified at budget time. Age alone is not always the determining factor as to when equipment should be replaced. Production and utilization records and maintenance costs to keep the equipment operational may be used to substantiate the need for replacement.

  Additional equipment often is required when additional staff are hired. One will usually justify the other. Often the need for newly developed equipment to cope with a specific condition will become apparent. Here again the best justification may be found in your records.

- Materials. Past requirements and consumption based on records will provide the most accurate indication of future needs.

- Services. Budget time is when you should carefully analyze past expenditures for outside services. Your records could indicate they have increased to a point where it would be more efficient and economical to acquire staffing and equipment needed to perform such work in-house.

RENT A WORKER
$
$
$
$

- Analysis of Records. Good records can be easily analyzed and the results of analysis presented in tables, charts or graphs. These results often SHOW or ILLUSTRATE a budget need very effectively. To illustrate this point, let's examine an actual example of how Sacramento County justified the budgeting of an additional high velocity cleaner and crew.

  The wastewater collection system was divided into two portions for the purpose of developing a preventive maintenance schedule. One portion of the system was put on a one or two-year schedule while the other portion was put on a three to six-year schedule. The worst areas were included in the one to two-year schedule. Results from an analysis of records were PLOTTED as shown on Figure 12.16.

An examination of Figure 12.16 SHOWS that the portion on the one or two-year schedule had a significant reduction in the number of stoppages, but the portion on the three to six-year schedule was experiencing an alarming increase in the number of stoppages.

What caused the increasing number of stoppages? Certainly the frequency of cleaning is one answer. Were the stoppages caused by grease, roots or other problems? The answer to this question will tell you what types of equipment or adjustments in the preventive maintenance schedule are needed to reduce stoppages. Most of the Fig. 12.16 trends in number of stoppages in Sacramento County areas where the increases in stoppages occurred were lightly populated areas with large lots. Grease accumulation was the main cause of stoppages.

How can the number of grease stoppages be reduced? One more high velocity cleaner would allow Sacramento County to place almost the entire wastewater collection system on a two-year or more frequent preventive maintenance schedule as needed.

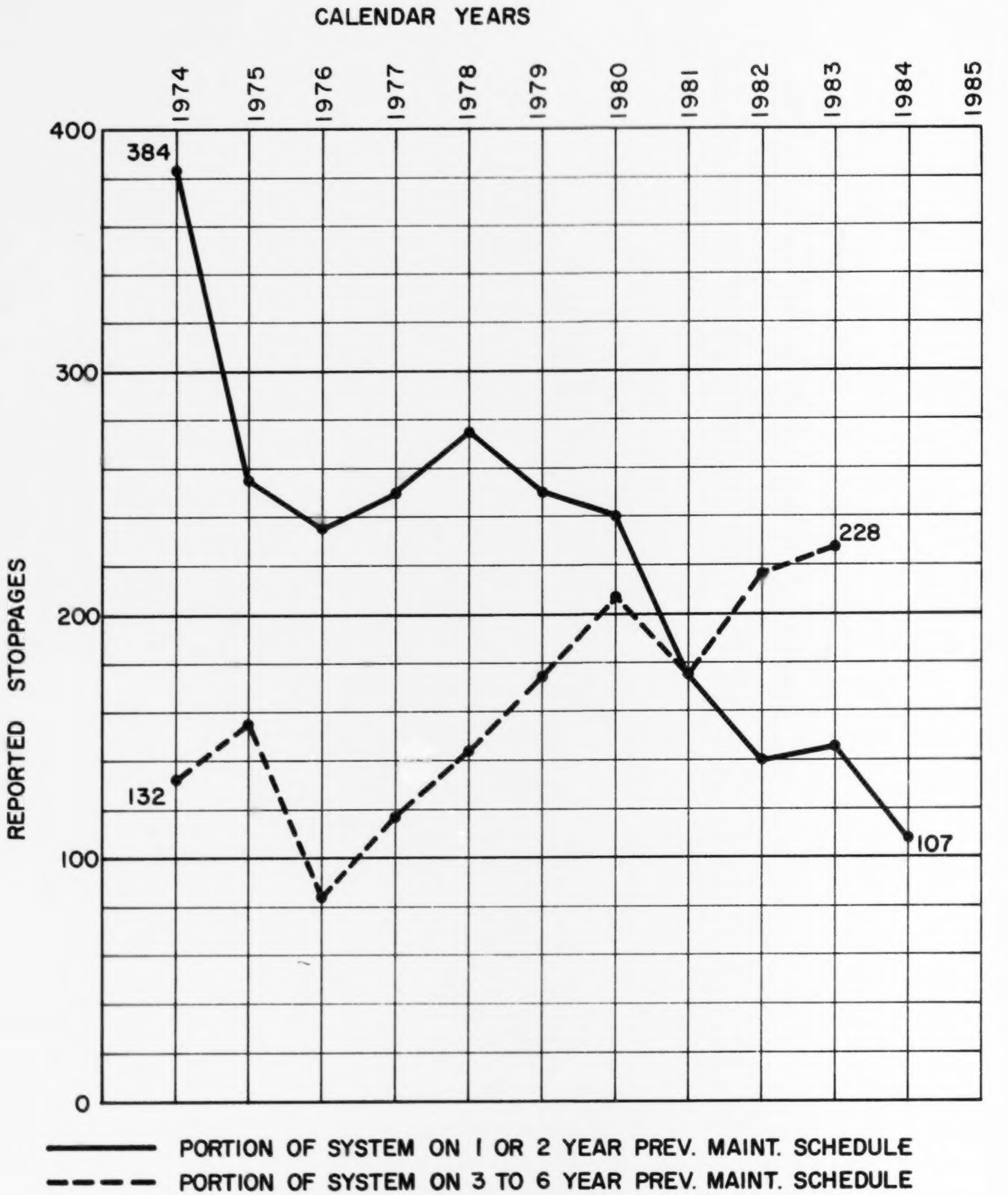
This pictorial analysis of results and logical analysis of the problem and proposed solution can be a very effective means of justifying your budget.

BASIS FOR CLAIM DEFENSE

The nature of our work exposes us to direct contact with the public and their private property. The public, in turn, will have daily contact with appurtenances of our collection systems which are in public right of ways. All these contacts provide many opportunities for either damage to private property or injury to the public through contact with a defective part of our system.

Aside from the fundamental necessity of exercising appropriate care and consideration while on private property and keeping our collection systems free of hazards, there is another thing we must do. We must keep adequate records to document our daily routines to a degree that will be of value in establishing our innocence or to disprove any negligence on our part should liability claims arise.

In event of such legal action, your records are certain to be examined in minute detail. Routine items such as dates, time, and identification numbers will suddenly become legal evidence documenting your actions or inaction. It is very important that you set up a system to check and double check these routine items on the hundreds, or thousands, of records generated throughout the year before they are filed to become a permanent legal record.



NOTE: STOPPAGES REDUCED FROM 384 TO 107 ON 1 AND 2 YEAR SCHEDULE.
STOPPAGES INCREASED FROM 132 TO 228 ON 3 TO 6 YEAR SCHEDULE.

Fig. 12.16 Trends in number of stoppages in Sacramento County

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 400.

12.7J List the two basic reasons for collection system records.

12.7K Records should be kept on what different cost items?

12.7L How can good records be helpful to persons preparing a budget?

12.7M Discuss the legal aspects of recordkeeping.

12.752 Types of Records

There are so many different types of records and special forms that can be useful to collection system operation and maintenance agencies that space will not allow detailed discussion of all of them in this section. Only a few of the most common will be presented or illustrated. With these examples you can prepare forms to meet your own special needs.

PERSONNEL

Records relative to personnel are common to all organizations.

- Personnel file. A separate file should be maintained for each individual employee. An important part of this file is an individual information sheet that provides such information as: date of employment, age, blood type, inoculations, dependents, and medical history for use in case of accident or serious injury. Keep these files up-to-date and confidential.

  Other information contained in personnel files may include work history, commendations, disciplinary actions, accidents, attendance records, performance evaluations, training courses, and certifications. The contents of personnel files must comply with your agency's personnel rules and regulations, any union contracts and legal requirements.

- Attendance. Data on attendance and reasons for leave during working hours can be obtained from the daily work reports. A superintendent or supervisor may use these records to counsel operators who are abusing their leave privileges or are taking unauthorized leave. Excessive use of leave, especially on Fridays and Mondays, may indicate problems that can be addressed before an employee's work performance would require termination.
- Assignments. A record of an operator's work assignments over a period of time, developed from work reports, is useful when considering exposure of the employee to the various work experiences possible for career development.
- Pay. Personnel pay records developed from payrolls are used to provide employees with an annual accounting of their pay and withholdings, answer questions they might raise about past pay, and to provide a history that is useful in planning pay adjustments.

EQUIPMENT

Equipment records fall into the following three main categories:

- Equipment Inventory and Depreciation. An equipment inventory record provides an accounting of the type and cost of equipment owned by a collection system agency and, as illustrated by Figure 12.17, provides information on repairs and depreciation of equipment.
- Preventive Maintenance. A preventive maintenance record system includes a schedule of routine maintenance, user-generated requests for special maintenance, and a history of maintenance and repairs performed. The maintenance record must include costs since they become a part of the cost of operating a piece of equipment.
- Use. Refer to Figures 12.8 through 12.15 and you will note that each daily work report form has a space for reporting the equipment used to complete the work. This information is needed to record the total use of a piece of equipment and calculate the cost of the work performed.

MAIN SEWER LINE

Records for lateral, main, trunk and interceptor sewer lines all fall into the main sewer line record category and include the following:

1. Main Line Inventory. The type of information that should be included in a main line inventory, as illustrated by Figure 12.18, consists of:
   - Identification of a line segment using the discrete (individual) numbers of the upstream and downstream manholes.
   - Size and length of the line segment, depth of the line at the upstream and downstream manholes, type of material and the line's location (street or easement).
   - Designation of the area of the collection system agency containing the line segment.
   - The "as-built" map reference number, year built, and the date of the last television survey.
   - The line inverts at the upstream and downstream manholes and the map coordinates of these manholes (if known).
2. Main Line Maintenance History. Record the history of maintenance by line segments, as illustrated by Figure 12.19 (the code number designations are shown on the bottom of Figure 12.10), and include:
   - Date of a maintenance activity during a period of years, usually six to eight years.
   - The type of equipment used for maintenance activity.
   - The time taken to perform the maintenance activity.

EQUIPMENT DEPRECIATION RECORD

YR. DEPN. ENDS	DEPARTMENT	EQUIPMENT	ASSET NO.

DESCRIPTION	INITIAL LOCATION		TRANSFERS		
	DEPT.				
	BLDG.				
	FLOOR				
	DATE				

TYPE OF DRIVE	POWER	H.P. REQD.	FLOOR SPACE	WEIGHT	MEMO
DATE ACQ.	BOUGHT FROM			MFRS. NO.	P.O. NO. / VOUCHER NO.
EST. LIFE YRS.	ANNUAL DEP'N. RATE % AMT.		APPRAISAL PAGE		

COST DETAILS	ORDER NO.	AMOUNT	DEDUCTION RECORD	
NET COST			DATE DEDUCTED SCRAPPED ☐ SOLD ☐ TRADE-IN ☐	
FRT. & CART.			COST	
INSTALLATION			ACCRUED DEPRECIATION	
			DEPRECIATED VALUE	
			SELLING PRICE	
			PROFIT OR LOSS	

REPAIR RECORD

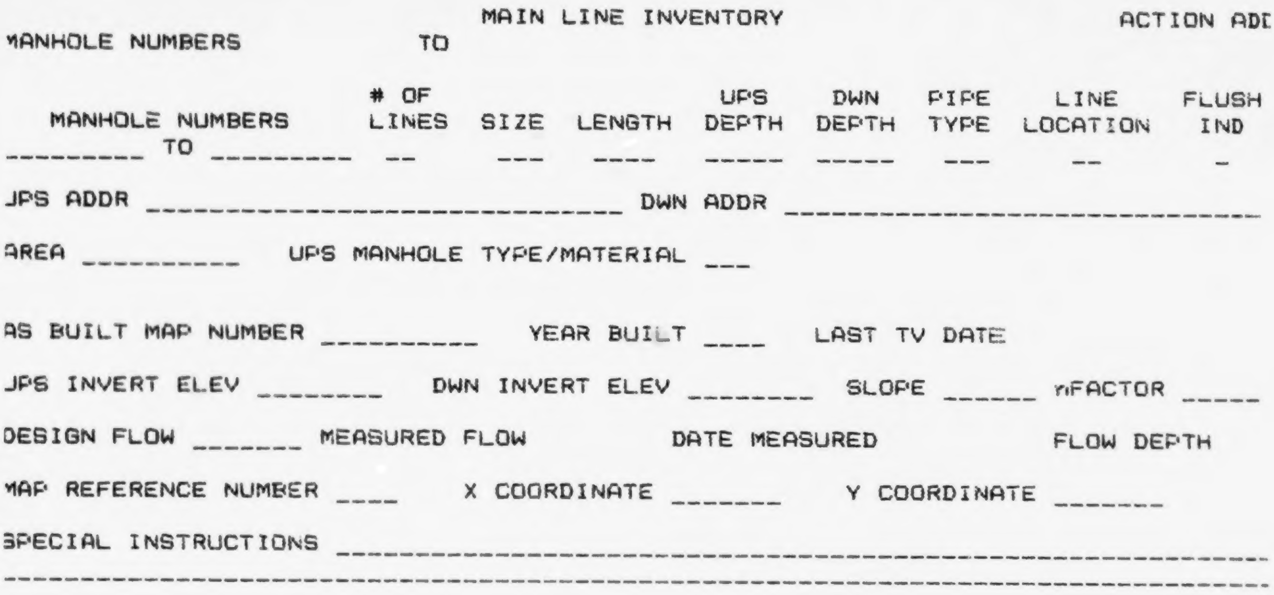
DATE	S. O. NO.	AMOUNT	DATE	S. O. NO.	AMOUNT	DATE	S. O. NO.	AMOUNT	DATE	S. O. NO.	AMOUNT

The UTILITY Line Form No. 25-239

ASSET NO.	EQUIPMENT	ANNUAL DEPN. RATE % AMT.	YR. DEPN. ENDS

DATE	REFERENCE	ASSET			DEPRECIATION			NET BOOK VALUE
		DEBIT	CREDIT	BALANCE	DEBIT	CREDIT	BALANCE	

Fig. 12.17 Equipment inventory and depreciation record



MAIN LINE INVENTORY

MANHOLE NUMBERS TO ACTION AD

MANHOLE NUMBERS	# OF LINES	SIZE	LENGTH	UPS DEPTH	DWN DEPTH	PIPE TYPE	LINE LOCATION	FLUSH IND
---------- TO ----------	--	---	----	-----	-----	---	--	-

UPS ADDR ________________________________ DWN ADDR ________________________________

AREA __________ UPS MANHOLE TYPE/MATERIAL ___

AS BUILT MAP NUMBER __________ YEAR BUILT ____ LAST TV DATE

UPS INVERT ELEV ________ DWN INVERT ELEV ________ SLOPE ______ nFACTOR _____

DESIGN FLOW _______ MEASURED FLOW DATE MEASURED FLOW DEPTH

MAP REFERENCE NUMBER ____ X COORDINATE _______ Y COORDINATE _______

SPECIAL INSTRUCTIONS ____

____

Fig. 12.18 Main line inventory

- Types, severity and estimated weight of debris removed by the maintenance activity.
- Condition of the line by type of problem and severity observed at the upstream and downstream manhole at the time of the maintenance activity.
- The reason for the maintenance activity.

3. Television History. A good example of the television history for a main sewer line segment is illustrated by Figure 12.20. The history includes:
   - Date of the television survey.
   - Video tape number and file location on the tape containing the survey.
   - Observed condition and cleanliness of the line grade and the direction of travel of the television camera.
   - Footage from entrance of manhole to recorded observation.
   - Observed tap location in code, water level in inches, root intrusion (rate 1 for light to rate 9 for extra heavy), amount of grease deposits (light, medium and heavy), pipe conditions, and any other important conditions in code.
   - Remarks on observations not covered by the previous conditions.
   - The illustrated form also notes work orders issued as a result of the recorded television survey.
4. Main Line Stoppages. One measure of the effectiveness of a preventive maintenance program for a collection system is the number of main sewer line stoppages that occur. What is the annual number of stoppages in your collection system (see Figure 12.16)? If the number of stoppages is increasing, identify the locations of these main lines having stoppages and increase the maintenance of these lines. You will have to decide the acceptable number of stoppages for your collection system and work toward that number since no practical preventive maintenance program will eliminate all stoppages.

   Microcomputer software, such as the previously referenced package produced by Hansen Software, Inc., records main stoppages by date and line segment. The program also records the causes and actions taken to remove the stoppages.

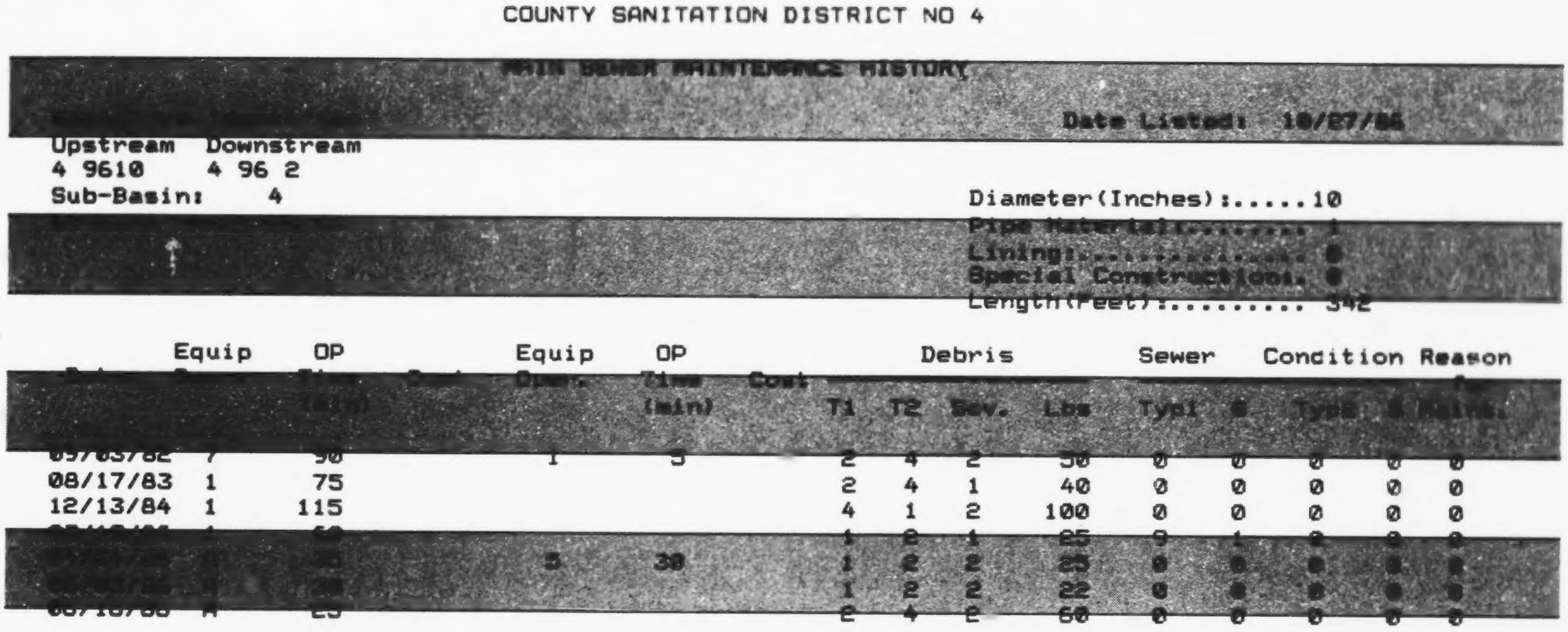
SERVICE SEWER LINES

Records for building service sewer lines are similar to records for main sewer lines and include the following:

- Service Line Inventory. Service lines are inventoried by assessor's parcel number (if available) and street address. Records should also provide the main line segment to which it is connected and the location of cleanouts used for maintaining the agency's part of the service line.
- Service Line Maintenance History. Record the history of service line maintenance by individual lines (generally identified by property address) and include the date of a maintenance activity, the reason for it, type of maintenance performed, and time spent on the activity.

TIME, MATERIALS AND EQUIPMENT

Time used by personnel on the activities of a collection system agency are recorded for each activity and used as needed to produce production and cost reports. Time records can also be used to analyze the use of personnel and to plan for rotation of work assignments.



COUNTY SANITATION DISTRICT NO 4

MAIN SEWER MAINTENANCE HISTORY

Date Listed: 10/27/86

Upstream Downstream
4 9610 4 96 2
Sub-Basin: 4

Diameter(Inches):.....10
Pipe Material:.......... 1
Lining:............... 0
Special Construction:. 0
Length(Feet):......... 342

Date	Equip Oper.	OP Time (min)	Cost	Equip Oper.	OP Time (min)	Cost	Debris T1	T2	Sev.	Lbs	Sewer Type	%	Condition Type	%	Reason for Maint.
09/03/82	7	90		1	5		2	4	2	50	0	0	0	0	0
08/17/83	1	75					2	4	1	40	0	0	0	0	0
12/13/84	1	115					4	1	2	100	0	0	0	0	0
[illegible]	1	[illegible]					1	2	1	25	9	1	0	0	0
[illegible]	[illegible]	[illegible]		5	30		1	2	2	25	0	0	0	0	0
[illegible]	[illegible]	[illegible]					1	2	2	22	0	0	0	0	0
[illegible]	[illegible]	25					2	4	2	60	0	0	0	0	0

Fig. 12.19 Main line maintenance history

```
                 R. J. HANSEN, INC. DEMONSTRATION DATA BASE
                             TV HISTORY HARDCOPY

REPORT DATE 11/14/86                                REQUESTED BY J CLEARWATER
REPORT NO.  WC1R14                                                   PAGE   1
                      FROM 5044-1696 TO 5044-2120


MANHOLE NUMBERS   5044-1696   TO   5044-2120
MANHOLE ADDRESS   444 TAHOE KEYS DRIVE    TO   555 TAHOE KEYS DRIVE
LOCATION S    SIZE    8   TYPE VCP   UPS DEPTH  5.2   DWN DEPTH  5.5   LENGTH  424

TV DATE 10/29/83    PRIOR HISTORY N    VTR NO. 94     VTR INDEX 0.00 TO 15.6
GRADE P    CLEANLINESS G    CAMERA DIRECTION D

FOOT TAP WTR ROOT                                   --------WORK ORDER--------
READ LOC LEV RATE GR   OC         REMARKS           WO PROB  BY ACT P COMPLETE

 M/H       0           CL NEW LINE-EAGLE VALLEY CONSTR
   7  34   0              ROUGH JOINT
 100       0   8    L
 102       0           OJ
 150  12   0   8    L  RJ                           UM  RTS 027  PR 2 11/15/83
 196  34   2        L     STANDING WATER
 200       0   2          LIGHT ROOTS
 300  34   0   8    L  PT 1/2" PROTRUDING TAP
 355       2              STANDING WATER
 360       0        M     OUT OF WATER
 384  12   3              SWALE CAUSING GREASE BLDUP
 424       0           EP
 426       0           CL CENTER LINE OF M/H
```

Fig. 12.20 Television survey history

Material use records, by activities and jobs, account for the depletion of inventoried supplies and allows the calculation of the cost of activities and jobs.

Equipment use records, also by activities and jobs, are developed from work reports and are used to determine the amount of time a piece of equipment has been operated. This data serves as a basis for determining the hourly operating cost of the equipment. Equipment use records are also used to assign operating costs to the appropriate activities and records.

ADDITIONAL RECORDS

A few records common to the operation and maintenance of most collection systems have been described. Additional records may include the following:

- Accidents involving agency personnel and equipment,
- Backflow of wastewater onto private property and into watercourses,
- Safety training activities,
- Job-related training, and
- Personnel actions.

Accident records are very important. Workers Compensation claims require complete reports. Supervisors and superintendents need to know the safety record of their agency, as well as records for crews and individuals. Records of events in an accident might be useful as a legal defense against liability claims and against charges of agency negligence if approved safety procedures are followed and specific action is consistently taken (and recorded) to prevent similar accidents in the future.

12.753 Retention of Records

The superintendent of a wastewater collection system must know which records are to be retained, and for how long, to comply with state and federal regulations. Also records should be kept as long as they are thought to be useful or may be needed for defending claims for injuries or property damage submitted to an agency. Ask your legal counsel to provide guidance for retention of records.

Records that are retained on electronic computer disks and tapes do not use a lot of space, but they should be labeled and filed in a manner that will facilitate their use. Printed records are bulky and do require considerable storage space. You may want to consider microfilming printed records to reduce the storage space of this type of record.

Essential records should be protected from loss by appropriate storage including fireproof filing cabinets, vaults and a safe deposit box in a local bank.

12.754 Responsibility for Records

Forms can be designed to record all the necessary information that could ever possibly be needed, but this alone will not guarantee a good recordkeeping system. To create a functional recordkeeping system, all personnel involved must accept some measure of responsibility for their part in the system.

SUPERINTENDENT

Since a superintendent will derive the most direct benefit from good recordkeeping, the superintendent should be the most concerned. Concerns should include the following items:

- What is required. The superintendent should decide what records will be needed to meet job responsibilities. Control must be exercised over what amount of detail the records should include and which specific activities will require recordkeeping procedures.
- Use. Constantly be aware of the degree to which records are being used. Some records, after they are initiated, may become unnecessary because of changing conditions or policies. Promptly discontinue using any such records.
- Quality. A superintendent should be constantly alert to the level of compliance with recordkeeping policies. Periodically monitor the daily recordkeeping activities of all personnel — operators and staff alike. By examining all records closely for a period of four or five days, you will be better informed and will communicate your serious concern about accurate records to the entire agency staff.

COLLECTION SYSTEM OPERATORS

A majority of operational records originate in the field as work reports prepared by the collection system operators. Operators must understand their responsibility for submitting accurate and neat reports in a timely manner.

- Accuracy. Reports MUST be accurate. One digit in an address or identification number when omitted, unreadable, or reversed can make a report card practically useless.

- Legibility. Adverse working conditions and wet weather often make it difficult to produce legible reports. Excuses for illegible reports are often valid. Collection system operators should be allowed ample time and proper facilities to allow them to complete and turn in neat reports.
- Promptness. Collection system operators often develop a habit of completing their reports at the end of the day. This is especially true when crews perform work at several different locations during the day. The most effective method of completing a report is at the scene of each job when all the facts and circumstances are available and obvious.
- Quality. Collection system operators can and will comply with the foregoing standards. Much of the information reported will benefit operators doing future work. Collection system operators understand this and appreciate the value of good records. A supervisor should never accept less than full compliance with the above standards. Collection system operators will soon realize the concern with accuracy is for their benefit, and they will begin to take pride in the quality of their reports. Praise operators when they submit quality reports and explain what is needed when poor reports are submitted.

OFFICE PERSONNEL

Ultimately, most records are processed by office personnel and they, too, share the responsibility for keeping the system accurate and up-to-date.

- Availability. Records need to be prepared and filed in such a manner as to provide planning information quickly to supervisory personnel and operators. Processing should be on a daily basis if possible.
- Familiarity. Office personnel must become familiar with the nature of reported collection system work and how the records are used. It will help them to understand the importance of records and will greatly improve the cooperation between them and collection system operators.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 400.

12.7N What kind of information should be contained on an individual's fact sheet in a personnel file?

12.7O What information should be included on a television survey history form?

12.7P How long should records be kept?

12.76 Reports for Planning and Controlling

In a management information system, records developed from work reports are processed by staff personnel (generally assisted by microcomputer systems) into reports used by superintendents and supervisors for planning and controlling the operation and maintenance of a wastewater collection system.

12.761 Need for Report

The superintendent of a collection system needs to have reports analyzing records on manpower, materials and equipment use to initiate actions to improve work efficiency and prepare budgets. Reports on main sewer line stoppages are used to plan and modify a collection system's preventive maintenance program. Main and service sewer lines' maintenance history reports are used to determine the need for future maintenance and to order appropriate repairs or replacements. A superintendent should have other reports prepared as their need for effective planning and controlling becomes apparent.

A supervisor of collection system operators needs reports on main sewer line stoppages and main and service sewer line maintenance history to plan preventive maintenance activities and to schedule routine cleaning and inspection of a collection system with cleaning and TV equipment and operating crews. These reports are also used to assign priority to work orders received, if not prioritized by a superintendent. A supervisor will find the need for other reports for conferences with management on policy and technical matters and training collection system operators.

12.762 Types of Forms and Reports

Superintendents and supervisors of collection systems will determine the types of forms for planning and controlling reports they will need for their particular management methods and system. The following are some of the commonly used reports produced by the *WASTEWATER COLLECTION MANAGEMENT SYSTEM* microcomputer software available from Hansen Software, Inc.

MAIN LINE HISTORY

A comprehensive report of the maintenance performed can be produced for a requested main line segment. The user of the report can interact with the computer while viewing the report to produce a work order for further maintenance of the main line segment.

SERVICE LINE HISTORY

A comprehensive report of the maintenance performed can be produced for a requested service line. The user of the report can also request the production of a work order for further maintenance of the service line.

MAIN LINE SCHEDULED MAINTENANCE REPORTS

The several types of reports under the Main Line Scheduled Maintenance Reports category are:

- Main Line Scheduled Maintenance Work Orders. This report should be generated each month. For each main line that is due for preventive maintenance, the system will create an open activity record on the main line history record, reschedule a preventive maintenance activity for the prescribed maintenance interval, and generate a work order if requested by the computer operator.
- Incompleted Main Line Scheduled Work Orders. This report will provide a list of all incompleted main line scheduled work orders currently existing.
- Completed Main Line Scheduled Work Orders. This report will provide a list of all main line scheduled work orders completed within a given date range.
- Projected Main Line Scheduled Work Orders. This report will provide a projection of the future main line scheduled maintenance work load.

MAIN LINE UNSCHEDULED MAINTENANCE REPORTS

Reports under this category are:

- Incompleted Main Line Unscheduled Work Orders in Priority-Day Sequence. This report will provide a list of the outstanding (not finished) unscheduled work orders for main lines. Work orders are listed in ascending order of priority and descending initiated date, as illustrated by Figure 12.21.
- Incompleted Main Line Unscheduled Work Orders in Priority-Line Sequence. This report will provide a list of the outstanding unscheduled work orders for main lines by ascending priority and ascending manhole number.

```
                    R. J. HANSEN, INC. DEMONSTRATION DATA BASE
        INCOMPLETED MAIN LINE UNSCHEDULED WORK ORDERS IN PRIORITY-DATE SEQUENCE

REPORT DATE 11/14/86                                     REQUESTED BY J CLEARWATER
REPORT NO.  WC1R03                                                       PAGE    1

                PRIORITY 1     INITIATED FROM 01/07/86 TO 06/30/86

PRIORITY 1  CRITICAL/EMERGENCY

        ---MANHOLE NUMBERS--      ------INITIATED------
           FROM        TO          DATE     SOURCE   BY       PROB
        5044-1696  5044-2120     04/07/86     S      027       RTS
        7B05-9343  7B05-8969     04/04/86     S      027       GRS

                 2 INCOMPLETED UNSCHEDULED WORK ORDERS FOR PRIORITY 1
```

Fig. 12.21 Report of incompleted main line unscheduled work orders in priority-date sequence

- Completed Main Line Unscheduled Work Orders. This report will provide a list of all main line unscheduled work orders completed within a given date range.
- Print Previously Generated Main Line Unscheduled Work Orders for Area. This report will print all incompleted main line unscheduled work orders previously generated on the Main Line History Record of a given area.

SERVICE LINE REPORTS

Reports under this category are:

- Incompleted Service Line Unscheduled Work Orders. This report will provide a list of the outstanding unscheduled work orders for service lines.
- Completed Service Line Unscheduled Work Orders. This report will provide a list of all service line unscheduled work orders completed within a given date range.

AREA REPORTS

The reports relating to collection system areas are:

- Area Scheduled Maintenance Work Orders. This report should be generated each month. For each area that is due for preventive maintenance (of all main lines within the area), the system will create an open activity on the area history record, reschedule the preventive maintenance activity for the maintenance interval prescribed and generate a work order.
- Incompleted Area Scheduled Work Orders. This report will provide a list of all incompleted area scheduled work orders currently existing.
- Completed Area Scheduled Work Orders. This report will provide a list of all area scheduled work orders completed within a given date range.
- Projected Area Scheduled Work Orders. This report will provide a projection of the future area scheduled maintenance work orders.

MISCELLANEOUS REPORTS

The category of miscellaneous reports includes:

- Main Line Stoppage Summary. This report will provide a summary of all main line stoppages for a given date range.
- Main Line Stoppages. This report will provide detailed information about main line stoppages for a given date range and/or area.
- Selected Main Line Stoppages. This report will provide a list of main lines which have a given number of stoppages (or more) within a given date range as illustrated by Figure 12.22.
- TV History Hard Copy. Figure 12.20 illustrates the hard copy (printed) of a TV survey history of a given line segment. Hard copies are printed when there is a need to file the information in the traditional manner.

The Hansen *WASTEWATER COLLECTION MANAGEMENT SYSTEM* software also contains a Query Retrieval System which provides access to all the collection system records in the data base. The purpose of the system is to allow the user to create customized reports to meet the informational needs not met by the Wastewater Collection Management System (WCMS) products.

OTHER REPORTS

Other reports commonly used for planning and controlling the operation and maintenance of a collection system include:

- Production. A primary concern for any superintendent and supervisor is crew productivity. The supervisor must be kept informed at all times on the progress and production of assigned operators. Management may require supervisors to submit reports documenting production. The following paragraphs describe the types of reports a supervisor might be asked to prepare.
- A monthly report from each individual foreman. These reports should include daily production activity of each of the crews under each foreman. Activities may include balling, rodding, TV inspection, construction and repairs, or any other significant maintenance activities that are part of the agency's maintenance program.
- A monthly report of the unscheduled work load. Indicate the number of calls answered and the number of main line stoppages encountered. List stoppages according to their cause such as roots, grease, or other appropriate categories.

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                 R. J. HANSEN, INC. DEMONSTRATION DATA BASE
                       SELECTED MAIN LINE STOPPAGES

REPORT DATE 11/14/86                                REQUESTED BY J CLEARWATER
REPORT NO.  WC1R19                                                  PAGE    1
                 FROM 07/01/83 TO 06/30/86  NO. OF STOPPAGES  3

     --MANHOLE NUMBERS--     DATE OF LAST     --PM--      NUMBER OF
       FROM        TO          STOPPAGE       HC   PR     STOPPAGES

     5044-1696 5044-2120       04/07/86       12                3
     7B04-9867 7B05-9462       04/05/86       6                 3
     7B05-8638 7B05-8290       06/28/84            12           3
```

Fig. 12.22 Report of selected main line stoppages

- Budget. Superintendents share some responsibility for the preparation and submission of the budget. For the supervisor this usually means completing budget forms provided by management or accounting departments. All budgets require accurate information about production and anticipated work loads. The above-described reports will be very helpful in providing such information.
- Cost of operation. A report on how budgeted funds were or will be spent is very important. This report should describe the total cost of operation as well as costs for supplies, materials, equipment and salaries. Costs also can be reported by types of programs such as clearing emergency stoppages, preventive maintenance, responding to complaints and repairs.
- Problems. A record of problems encountered is important so problems can be anticipated or prevented from occurring in the future.

- Personnel. In most organizations, personnel reports are primarily the responsibility of a personnel or accounting department. However, some reporting forms relative to operators that should be of direct concern to the supervisor include:
  - Performance reports,
  - Accident reports, and
  - Attendance analysis reports. An attendance report per se may not be very informative. An analysis of that report by a supervisor may indicate a pattern of absences which would suggest some corrective action on the part of the supervisor to be advisable.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 400.

12.7Q What kinds of reports does a superintendent of a collection system need and why?

12.7R What kinds of information are provided by computer-generated "service line reports?"

12.7S What is a "query retrieval system?"

12.7T What information should be contained in the monthly reports from each individual foreman?

12.77 Work Directives

The last element in a management information system is the work directives issued for the operation and maintenance of a wastewater collection system as illustrated in Figure 12.7.

12.771 Need for Directives

The operators of a collection system agency are responsible for using their time, materials, and equipment in an efficient manner on the work assigned to them. Superintendents and supervisors have the responsibility to direct, by assignment, the work of collection system operators in a manner that will lead an agency to its objectives and goals. Considering the operation of a football team helps to explain the need for work directives. The "operators" of a football team are the linemen and backs, whereas "management" consists of the supervising quarterback on the field and the superintending coach on the sideline. Together they act as a team with the common objective of moving the football over the goal line. Operators may make suggestions in the huddle if they detect something that will affect the team's actions, but they do not call the plays.

A superintendent and supervisors of a collection system, supported by planning and controlling reports produced by a good management information system, are in a position to make informed decisions and direct operators toward the agency's objectives and goals.

12.772 Types of Directives

Work directives given by a superintendent and supervisors to operators include training in work performance and equipment operation, standard operating procedures and work orders. Work directives should generally be in written form to reduce the possibility of misunderstanding and to provide a record for reference if questions arise about a directive. Verbal work directives can be used when they are more timely and efficient than the written type. The following examples illustrate two types of work directives given to collection system operators.

RESPONSE TO SERVICE REQUESTS

The standard operating procedure (issued by a superintendent) for responding to a request from a property owner for service is as follows:

- Service Request Report. The clerk receiving a request for service from a property owner obtains the information needed to fill out a SERVICE REQUEST REPORT, Figure 12.23, and gives it immediately to the supervisor of the service crew.
- The supervisor, on receipt of a service request report, immediately obtains any additional information needed for response to the request, makes a personal investigation if required, and gives directions to a service crew for responding to the service request. The directions may be in the form of a written work order, transmittal of a SERVICE REQUEST REPORT, or by radio communications as the priority of the request requires. In all instances, the supervisor gives the crew leader as much information as available for assisting in the response and indicates when the crew is expected to respond.
- The service crew is to respond to a request for service as directed by a supervisor. On determining the conditions pertaining to a service request, the crew performs the action needed to provide the requested service if it is the agency's policy to provide the service. If the service is not provided by the agency, the crew leader explains the agency's policy to the property owner and offers any appropriate suggestions on how the service might be obtained. The crew leader directs any unanswered questions concerning action on a service request to the supervisor. Upon completing action on a service request, the service crew leader completes the "Response" part of the

SERVICE REQUEST REPORT

REQUEST
From:

Name ______________________ Date __/__/__

Address ______________________ Time ________

Telephone __________ Parcel No. ______________

Nature of Request ______________________

Additional Information ______________________

Request Received By ______________

RESPONSE

Assigned To __________ Arrival Time __________

Conditions Found ______________________

Action Taken ______________________

Daily Work Report Reference ______________________

Fig. 12.23 Service request report

SERVICE REQUEST REPORT and submits the report along with the daily work report for the day the service action was performed.

- Supervisors submit completed *SERVICE REQUEST REPORTS* to the records clerk weekly.

WORK ORDERS

The physical makeup of the form will vary with the particular needs of each agency. They can be prepared in single, duplicate, or any required number of copies. An advantage of duplicate or carbon copies is that the original copy can be retained in the office as a check to verify that the duplicate copies in the field are returned and properly filled out when completed. Duplicates or carbon copies are not needed with computer systems because the original copies are retained in the computer for anyone who needs them. For an example of a simple work order form, see Figure 12.24.

Some microcomputer systems for management of collection systems will also produce work orders using information stored in their data base. Figure 12.25 is an example of such a work order.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 400.

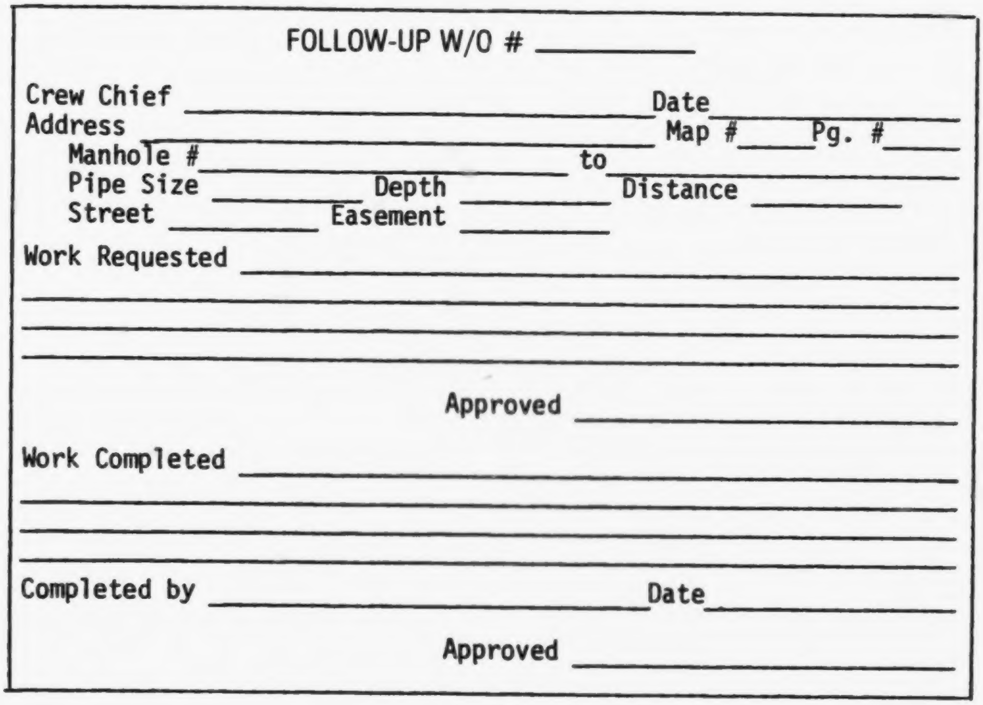
12.7U What types of work directives are given by superintendents and supervisors to operators?

12.7V What should a collection system supervisor do upon receipt of a "service request report?"

12.7W What should a crew leader do upon discovery that the agency's policy prohibits correcting a problem in a service request?

12.7X Why are duplicates or carbon copies of work orders not needed when using a computer system?

12.7Y List the most important aspects of effective administration or supervision for persons working with wastewater collection systems.



FOLLOW-UP W/O # __________

Crew Chief ______________________________ Date __________

Address ______________________________ Map # _____ Pg. # _____

Manhole # ______________________ to ______________________

Pipe Size __________ Depth __________ Distance __________

Street __________ Easement __________

Work Requested ____

____

____

____

Approved ____________________

Work Completed ____

____

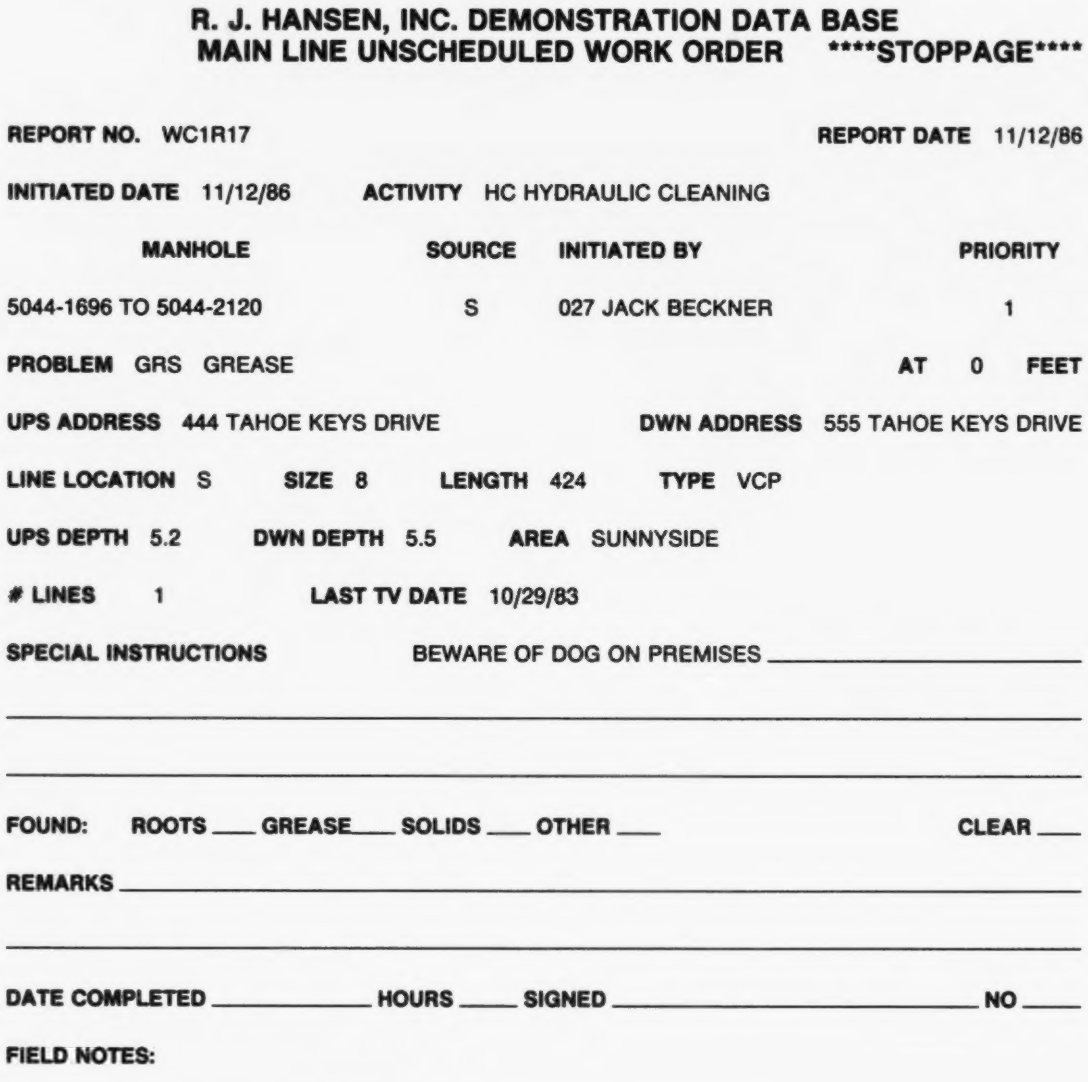
____

____

Completed by ______________________________ Date __________

Approved ____________________

Fig. 12.24 Work order form



R. J. HANSEN, INC. DEMONSTRATION DATA BASE
MAIN LINE UNSCHEDULED WORK ORDER ****STOPPAGE****

REPORT NO. WC1R17 **REPORT DATE** 11/12/86

INITIATED DATE 11/12/86 **ACTIVITY** HC HYDRAULIC CLEANING

MANHOLE	**SOURCE**	**INITIATED BY**	**PRIORITY**
5044-1696 TO 5044-2120	S	027 JACK BECKNER	1

PROBLEM GRS GREASE **AT** 0 **FEET**

UPS ADDRESS 444 TAHOE KEYS DRIVE **DWN ADDRESS** 555 TAHOE KEYS DRIVE

LINE LOCATION S **SIZE** 8 **LENGTH** 424 **TYPE** VCP

UPS DEPTH 5.2 **DWN DEPTH** 5.5 **AREA** SUNNYSIDE

# LINES 1 **LAST TV DATE** 10/29/83

SPECIAL INSTRUCTIONS BEWARE OF DOG ON PREMISES ____________________

____

____

FOUND: **ROOTS** ____ **GREASE** ____ **SOLIDS** ____ **OTHER** ____ **CLEAR** ____

REMARKS ____

____

DATE COMPLETED __________ **HOURS** ____ **SIGNED** ____________________ **NO** ____

FIELD NOTES:

Fig. 12.25 Main line unscheduled work order

DISCUSSION AND REVIEW QUESTIONS

Chapter 12. ADMINISTRATION

(Lesson 6 of 7 Lessons)

Write the answers to these questions in your notebook before continuing. The question numbering continues from Lesson 5.

29. Why do collection system superintendents and staffs need to be able to take effective action and make sound decisions concerning the operation and maintenance of the collection system?
30. What are the key factors involved in the development of an effective management information system?
31. When can work reports be discarded?
32. What information should be included in a preventive maintenance record system?
33. How should essential records be protected from loss?
34. Who is responsible for being sure your agency has a good recordkeeping system?
35. Why are work directives usually given in written form?

CHAPTER 12. ADMINISTRATION

(Lesson 7 of 7 Lessons)

12.8 REPORT WRITING

Now that you know how important reports are to a management information system, and also recognizing their importance for conveying information to the public and our fellow collection system professionals, consider writing a report on some aspect of collection system maintenance.

REPORT WRITING

12.81 Why You Need to Write Reports

Supervisors should have the ability to prepare a written account of the operation and maintenance activities under their responsibility. A report is a means to communicate information from the individual who has it to those who need it. Collection system operators are paid because somebody documented that the operators accomplished something.

If you are new operator to the wastewater field, you will be involved in report preparation from the beginning. Your field notes and daily work reports are usually the basis of information used by your supervisor to prepare written reports. Field notes and reports are useful only if they are complete, brief and clear.

Take a few extra minutes when each job is completed to fill out forms or make field notes to produce a clean, neat, readable report of the job just finished. A field report that cannot be read due to poor handwriting or poor printing, misread numbers, or writing smeared with mud is of no use to any agency. When a report form has been completed, a review by another crew member provides an easy check for legibility, correct identification of location (including street address), map references, size of lines, proper agency cost accounting codes, amount of time spent on job, and other important facts.

When you become a supervisor you will appreciate neat, readable field reports from your crews. Develop the ability to make your own reports neat and legible the first time. Take pride in accomplishing this important aspect of your work.

When faced with the prospect of preparing a written report, a supervisor may experience a feeling of apprehension or inadequacy because of what the supervisor may believe to be a lack of writing skill. Supervisors with many years of valuable experience and considerable knowledge and ability in the wastewater collection field, may reject the idea of putting their knowledge in writing because of this feeling of inadequacy as a writer.

For this reason we feel the emphasis should be placed on the "Reporting" aspect of the heading of this section. The information contained in the report, the knowledge and the experience that can be passed on to others through the report, these are the true objectives of "Report Writing." Your reports tell what you did to justify a public investment in your agency and what you plan to accomplish next year. If you have organized the information about your system into a usable and understandable form, you will find most of the work of writing a report has already been done.

12.82 How to Prepare a Report

Qualified technical writing reference material is your best source for the HOW of writing. Perhaps the heading for this section should be "WHAT goes into a good report?" This is where our emphasis is going to be placed. However, there are a few basic steps we can suggest in the preparation of a good report.

ORGANIZATION

Before you can organize your report you must first organize yourself and your thoughts. Ask yourself, what is to be the objective of this report? Am I trying to persuade someone of something? Am I simply communicating information? For whom is the report being written? How can I make it interesting to the particular group for whom the report is being prepared?

After you have answered the above questions, the next step is to prepare a general outline of how you intend to proceed with the preparation of the report. List not only topic material but try to list all of the topics. Then arrange the topics so there is a workable, smooth flow from one topic to the next topic. Do not attempt to make your outline perfect. It is just a guide. It should be flexible. It is better to include too much material in your outline than to miss important points. You will find that as you begin to write you will remove nonessential points and expand on the more important points.

You might, for example, outline the following points in preparation for writing a report on a smoke testing program.

- A problem condition of excessive infiltration or inflow was discovered.
- Smoke testing offered the prospective means of identification and location of points of inflow.
- Funds, equipment, and material were acquired.
- Operators were trained.
- Tests were conducted.
- Results and conclusions were reached.
- Corrective actions were planned and taken.
- Conclusion, the tests did or did not produce the anticipated results or correct the problem.

Once you are fairly sure you have included all the major topics you will want to discuss, go through your outline and write down the facts that you want to include on each topic. Remember, this is just an outline. As you work through it, you may decide to move material from one topic to another if it seems appropriate. Don't be concerned about writing complete sentences in your outline if you find it easier just to jot down ideas. The purpose of outlining is to help ORGANIZE ideas and facts.

When your outline is complete, you will have the essentials of your report. Now you need to tailor it to the audience that will be hearing or reading it. This is very important. Will the audience be the agency management? Citizens groups? Other collection system agencies? Consider the following suggestions to help you tailor a report for each of these groups.

1) Management. They will have specific interests, mainly related to cost effectiveness. A report to management should include:
   a) Summary giving essentials (one page at most),
   b) Procedures used or method of study,
   c) Analysis of data, including trends, and
   d) Conclusions.

   Management may only read items (a) and (d) so be sure the essential information you wish to communicate is clear and brief. Be sure to give complete cost figures. Did the benefits warrant the costs? As a result of the tests, can future expenditures be reduced? Backup information and field data can be placed in an appendix for those who need the details.

2) Other collection system agencies. They too will be interested in cost figures. They also will want to know how the tests were accomplished, the procedures involved, size of crew, type of equipment used, source and availability of equipment and materials, difficulties encountered and how they were solved. The results and the benefits to be realized are important, too.

3) Citizens groups. Their interest will be more general. What is a smoke test? Why is it needed? Is the smoke harmless? Will it injure their plants or pets? Must they be home when the tests are in progress? How does the smoke detect defects? If illegal connections are found, how will this affect the individual property owners? Will it inconvenience them? Who pays for the test? How much will it cost to repair defects?

Each of these reports could be prepared using your original general outline. Simply adjust the outline to best emphasize the particular points you feel would be of particular interest to each specific group involved.

COMPOSITION

In the composition of your report it is wise to keep in mind the purpose of your writing. You are not writing a story. You are writing a "Report." Confine your writing to the activities that took place, the experiences gathered, and the results achieved. Be honest and explain the advantages and limitations of any recommendations.

- Drafts. Don't expect your report to be perfect the first time. Follow your outline and write a rough draft. Maybe you should be concerned with putting down your ideas the first time. Reread your draft three to five days later. Critically think about what you are saying. Ask a friend to read your report. Reread it and consider the items listed in the remainder of this section. Each time you rewrite a portion it will become a little bit better. We rewrote this manual several times after we received comments and suggestions from many groups.
- Facts. Confine your writing to the facts and events which occurred. Include only figures and statistics necessary to make the report effective. Facts must be relevant to allow for proper interpretation in the summary, conclusions and recommendations. Do not clutter the report with a lot of irrelevant figures that had little influence on the end results. Place voluminous data in an appendix.
- Continuity. To be interesting and easily understood, a report must have continuity. You had a problem, you explored various means to identify the problem — where it was located, what it was — and determined the needed correction. Consider the example we offered involving the smoke test.

- Effective. To be effective, a report should achieve the objective for which it is designed. In our example we wanted to justify to management that the tests were cost effective. To the other agencies, we wished to share our experience and knowledge in a way that would be of benefit to them. To the citizens group, we wanted to educate them as to what we were attempting to accomplish with our tests and explain the direct benefits to be realized by the public involved.

Effective reports require that you present clear, concise facts in a logical sequence (continuity) that can be easily understood by the group to which they are being offered. As an example of how you can easily be tempted to deviate from these basic principles, consider the report to the citizens group. They will have little knowledge of how a modern collection system functions. It would be easy for you to wander from your main objective by attempting to explain your collection system in detail. Certainly they would be interested in such aspects as lateral lines, main lines, trunk lines, lift stations, velocities, gravity lines, force mains, maintenance problems such as roots, grease, and debris, maintenance procedures, maintenance equipment, and your entire operation. It would all be very interesting to them, but it was not the object of your report. A brief explanation of how excessive inflow overloads treatment facilities and results in increased treatment costs is all that is required to put across the main objective your report and the reason for the smoke test.

- Candid. Webster's definition of candid is "frank, straight forward." A good report must have this quality. You are aware of your capabilities and experience. Keep your report within these limits. Do not attempt to impress a group such as management or professionals by using language or terminology that is unfamiliar to you. Likewise, with citizens groups do not attempt to impress them with language familiar to you, but foreign to them.

You want your report to accomplish the objective for which it was intended. To do this it must be favorably accepted by those to whom it is presented. Candor, honesty, sincerity, and frankness will contribute greatly to the acceptance you seek. Anything less can only detract from your report and may invite unwanted skepticism or criticism.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 401.

12.8A What are the two main considerations when preparing a report?

12.8B Why is a good outline essential?

12.8C Why must the intended readers of the report be considered?

12.8D What is the purpose of preparing drafts of reports?

12.9 PUBLIC RELATIONS

As collection system operators, the very nature of our work puts us in direct contact with the public in many of our daily activities. Our entire collection system is largely located either in public right of ways or in easements on private property. It could even be said that most of our public relations start with a negative element. Our services are rarely sought when everything is functioning properly. To the motorist, whose schedule is upset by our activities in his or her right of way, our position is rarely positive. To the property owner or tenant, whose privacy is interrupted, or services disrupted, or landscaping rearranged, we can hardly be considered a positive element. We are challenged, and it can often be difficult; but through good public relations, we can convert these negative feelings into positive appreciation of our efforts.

12.91 Importance of Public Relations

A collection system maintenance agency could possibly function with little regard for its public relations. This attitude should not, however, be an acceptable philosophy. Collection systems are essentially public utilities. As operators of such utilities, we are public servants. Public service need not imply servitude. Our service should be provided with sincerity, courtesy and an understanding of our responsibility to the public's needs.

12.92 Aspects of Public Relations

In the course of performing our daily activities, there are many aspects of public relations to consider.

TELEPHONE

In most instances initial contact with our collection system agencies will be by telephone. Relating to the well known cliche of "first impressions," it is important that this first contact be a positive one.

- Basic courtesy. Good practice requires that persons answering incoming calls identify the organization and give their name, clearly and sincerely. Such response should not be hurried or mechanical, it should be personable and sincere. Let the person calling know that you are interested in what they have to say.

- Understanding. Realize the person calling, in most cases, has a problem. Try to understand their problem. Be sympathetic to their problem. Understand that they may be nervous, upset or even abusive. Your understanding and courtesy can only serve to calm them.

- Conclusive. Whenever possible, carry the conversation to an acceptable conclusion. If the caller's problem is within the agency's realm of responsibility, assure them that a crew will be dispatched to investigate their problem. If possible, try to tell the caller how soon the problem will be corrected. If the complaint is not within your jurisdiction, help the caller find the appropriate person to contact.
- Return calls. If the problem will require a return call, advise the caller of the approximate time the return call will be made. If the return call is to be made by others, such as a supervisor, advise the supervisor of the approximate time interval involved that you have given the caller. Management should be sure that someone calls back to verify that the action taken met requirements or explain why not.

PERSONAL CONTACTS

Our work demands that we have many personal contacts with the public we serve. Many such contacts will be made on their property at their home and, in most cases, at our convenience. Every effort should be made to make such contacts pleasant and positive for both parties.

- Appearance. The appearance you present may, for better or worse, suggest to the public what type of service they can expect from your organization and its operators. Provide operators with uniforms bearing the name of the organization and the name of the individual. Uniforms provide for a standard of neatness as well as a means of identification.

  Equipment also should appear clean and neat. An emblem, symbol, or informative signs on equipment help people recognize who you are and what you are accomplishing.
- Attitude. Proper attitude cannot be overrated. Sincere concern for the problems of the individuals contacted must be demonstrated. Understand the person's problem, and perhaps the person's ignorance of the problems involved. If the problem is within your area responsibility, advise the person when and how it will be solved. If the problem is not one to be handled by your department or agency, suggest proper alternative action which the individual may take to find a solution.
- Knowledge. Operators assigned to answering calls from the public must have and demonstrate the knowledge to effectively deal with such problems.

EQUALITY

Maintain a level of equality in the level of service you provide.

- Consistency of service level. Various organizations and agencies will provide different levels of service. For example, many agencies will be responsible only for main sewer line maintenance or repairs. House services from the building out to the sewer tap in the street or easement will be the sole responsibility of the property owner. Other agencies may assume responsibility for sewer services which lie in the right of way or easement. Whatever your agency's level of responsibility is, you should be consistent in the level of assistance you provide. Often maintenance crews are tempted to provide services beyond their responsibility. Temptation can come in a variety of forms, helpless little old ladies, pretty, amiable young ladies, or nice old gentlemen. Sometimes it is difficult for crews to refuse such pleas for extra consideration. You must try to impress on your operators the importance of giving the same level of service to all customers, regardless of personal feelings or circumstances.
- Explanation of limits of service. As noted earlier, various agencies will perform different levels of service and assume different levels of responsibility relative to private and public collection systems. Supervisors must provide their operators with clear and exact guidelines as to agency policy. Employees should be able to explain such policies and areas of responsibility effectively to the public they serve.

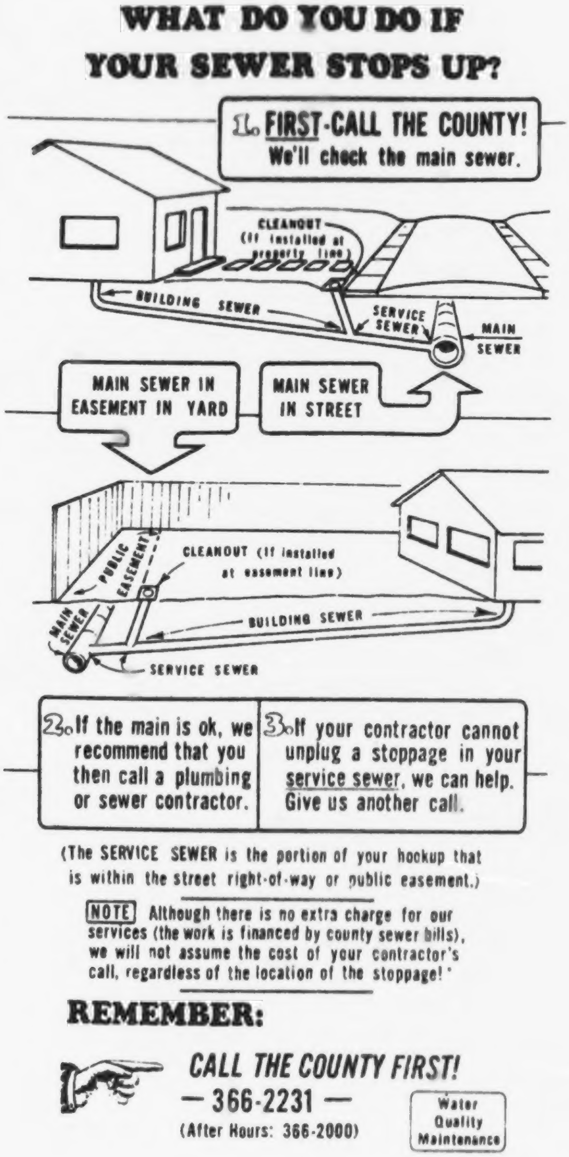
Figure 12.26 is a good example of a public relations piece used by Sacramento County, California, to explain its policy for service sewer maintenance.

12.93 Benefits of Good Public Relations

Good public relations must be earned, they cannot be bought. Once earned, your agency will enjoy the following benefits:

FROM THE PUBLIC

- Cooperation. Whenever it becomes necessary for maintenance operators to enter on private property, it is essential that the property owners cooperate. Good public relations can encourage this cooperation. Be considerate of private property at all times. Never enter on private property without first notifying the occupants as to your presence and the nature of your work. Seek their permission before entering their property. If no one is home and it has been necessary for you to enter onto their property in their absence, leave a note advising them of your actions and a telephone number they can call if they have questions or complaints about the condition of their property after your work has been accomplished. Impress upon your operators that the impression they leave with property owners will have a strong effect on the cooperation given to subsequent crews should it become necessary to reenter the same property.
- Understanding. The general public has little knowledge of the workings of a modern collection system. Few, if any, even are conscious of its location or existence until collection system operators appear on the scene to do some needed work. Collection system operators should take the time to explain briefly the location of the system, its function, and the need for their having access to it. Shown the courtesy of such explanation, the public will be more apt to understand the nature of our work and accept whatever inconvenience we might create for them.



WHAT DO YOU DO IF YOUR SEWER STOPS UP?

1. FIRST-CALL THE COUNTY! We'll check the main sewer.

CLEANOUT (If installed at property line)
BUILDING SEWER
SERVICE SEWER
MAIN SEWER
MAIN SEWER IN EASEMENT IN YARD
MAIN SEWER IN STREET
PUBLIC EASEMENT
CLEANOUT (If installed at easement line)
MAIN SEWER
BUILDING SEWER
SERVICE SEWER

2. If the main is ok, we recommend that you then call a plumbing or sewer contractor.

3. If your contractor cannot unplug a stoppage in your service sewer, we can help. Give us another call.

(The SERVICE SEWER is the portion of your hookup that is within the street right-of-way or public easement.)

NOTE Although there is no extra charge for our services (the work is financed by county sewer bills), we will not assume the cost of your contractor's call, regardless of the location of the stoppage!

REMEMBER:

CALL THE COUNTY FIRST!
— 366-2231 —
(After Hours: 366-2000)

Water Quality Maintenance

COUNTY POLICY REGARDING SEWER MAINTENANCE

1. CALL THE COUNTY FIRST

When sewer problems are experienced, the resident should first contact the County. We will check the main sewer and, if there is a cleanout existing at ground level, we will also inspect that to determine if the stoppage is in the service sewer or the building side. We will clear the stoppage if it is in the County part of the system. Otherwise, we will notify the resident.

2. PROPERTY OWNER'S RESPONSIBILITY

The owner of the property is responsible for keeping the sewer clear between the building and the cleanout, if there is one. If there is no cleanout at ground level, the owner is also responsible for clearing the service sewer to the main sewer. Locating the building sewer, and its connection to the service sewer is also the owner's responsibility, although we will attempt to assist with available records and information. We suggest the owner employ a plumbing or sewer contractor to clear any stoppages in the building or service sewer.

3. DEFECTIVE SERVICE LINE

If the contractor is unable to clear a stoppage due to a defect in the service sewer, we will repair it. If there is no cleanout to grade, the contractor must first expose the end of the service sewer at the easement or right-of-way line. The County will perform no work on private property except within a public easement.

4. COUNTY WILL INSTALL CLEANOUT

If the contractor was able to clear a stoppage in a service sewer, but, because there was no cleanout to grade, had to excavate the end of the service sewer, we will install a cleanout to facilitate clearing future stoppages. The contractor should contact us before closing the excavation.

5. DOUBLE WYE SERVICE

Where two properties are connected to a single service sewer by a double wye, the County will be responsible for maintenance of the shared service sewer.

6. LIMIT OF COUNTY RESPONSIBILITY

The County's only responsibility for work on private property is for damage caused by wastewater backup due to stoppage in the main sewer, or, in the case of a double wye installation, flow from the other property.

SLP-3(05/83)

Fig. 12.26 Explanation of service sewer maintenance policy

- Satisfaction. Collection systems must be operated to the satisfaction of the public they serve. Public relations that are effective can have an important influence on such satisfaction.
- Financial Support. The public will be more supportive when a collection system agency needs to increase its service charges or other sources of financing, if the agency has developed good public relations.

TO EMPLOYEES

Employees too will benefit from good public relations.

- Pleasant working conditions. A good relationship with the public will nearly always result in more pleasant working conditions for collection system operators. Being welcomed as conscientious, considerate, courteous, and essential operators, as opposed to being resented as incompetent, inconsiderate nuisances, will make the collection system operator's job more pleasant and satisfying.
- Recognition. Effective public relations will result in individual operators being recognized and commended by the public for work well done. Such recognition, when given, benefits everyone. The public appreciates the level of service which warrants such recognition, management feels its objectives and responsibilities are being carried out, supervisors are assured their efforts have not been in vain, and the operator is justly proud of a job well done.
- Morale. Public relations of a quality which produce cooperation, understanding, satisfaction, pleasant working conditions and recognition, improve the morale of the collection system personnel. The benefits to be had from such high morale will make any efforts of the supervisor to maintain good public relations well worth the time and concern.
- Self-perpetuating. Once established as normal procedure, good public relations and high personnel morale become self-perpetuating. A well satisfied public is eager to cooperate and operators whose efforts are recognized are constantly striving to improve their performance.

12.10 ADDITIONAL READING

1. *CONCISE GUIDE FOR WRITERS*, Glorfeld, L. E., Lauerman, D. A., 5th Edition, Holt, Rinehart and Winston, Inc., 383 Madison Avenue, New York, NY 10017. Price, $13.00
2. *MANAGEMENT OF LOCAL PUBLIC WORKS*, International City Management Association, 1120 G Street, NW, Washington, DC 20005. Price, $37.95.
3. *MICROCOMPUTERS IN PUBLIC WORKS*, American Public Works Association, 1313 E 60th Street, Chicago, Illinois 60637. Price, $60.00 members; $75.00 non-members.
4. *MANPOWER REQUIREMENTS FOR WASTEWATER COLLECTION SYSTEMS IN CITIES AND TOWNS UP TO 150,000 IN POPULATION*, Manpower Development Staff, Office of Water Program Operations, U.S. Environmental Protection Agency, Washington, DC 20460.
5. *MANPOWER REQUIREMENTS FOR WASTEWATER COLLECTION SYSTEMS IN CITIES OF 150,000 TO 500,000 IN POPULATION*, Manpower Development Staff, Office of Water Program Operations, U.S. Environmental Protection Agency, Washington, DC 20460.
6. *RECRUITMENT, RETENTION AND UTILIZATION OF PERSONNEL IN WASTEWATER COLLECTION SYSTEMS IN CITIES AND TOWNS WITH POPULATIONS UP TO 150,000*, Whate, Katie, A., Municipal Permits and Operations Division, Office of Water Program Operations, U.S. Environmental Protection Agency, Washington, DC 20460.
7. *OPERATION AND MAINTENANCE OF WASTEWATER COLLECTION SYSTEMS, MOP-7*. Available from Water Pollution Control Federation, 601 Wythe Street, Alexandria, VA 22314-1994. Order No. M00070H0. Price, members, $11.50; others, $15.00.
8. *PLANT MANAGER'S HANDBOOK, MOP SM-4*. Available from Water Pollution Control Federation, 601 Wythe Street, Alexandria, VA 22314-1994. Order No. MSM40H0. Price, members, $28.00; others, $34.00.
9. *PRIMER FOR COMPUTERIZED WASTEWATER APPLICATIONS, MOP SM-5*. Available from Water Pollution Control Federation, 601 Wythe Street, Alexandria, VA 22314-1994. Order No. MSM50H0. Price, members, $26.00; others, $35.00.
10. *THE STOCKWELL GUIDE FOR TECHNICAL AND VOCATIONAL WRITING*, Stockwell, Richard E., Addison-Wesley Publishing Co., Health Services Division, 2727 Sand Hill Road, Menlo Park, CA 94025. Price, $22.95.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 401.

12.9A Why are public relations important to collection system operators?

12.9B Describe how you should respond to telephone complaints.

12.9C How can an operator make positive personal contacts?

12.9D Why is equality of service important?

12.9E Who benefits from good public relations?

DISCUSSION AND REVIEW QUESTIONS

Chapter 12. ADMINISTRATION

(Lesson 7 of 7 Lessons)

Write the answers to these questions in your notebook before continuing with the Objective Test on page 402. The problem numbering continues from Lesson 6.

36. How does the collection system operator come in contact with the public?
37. What does "public relations" mean to you?
38. Why are public relations important to the collection system operator?
39. Why must the same level of service be provided for everyone?
40. Why are reports important?
41. How would you prepare and write a report for your supervisor?

SUGGESTED ANSWERS

Chapter 12. ADMINISTRATION

ANSWERS TO QUESTIONS IN LESSON 1

Answers to questions on page 324.

12.1A Discipline consists of obedience, application, energy, respect and behavior, all essential conditions for a smooth-running organization.

12.2A An effective administrative plan should consist of a mission statement, goals to be attained and the objectives, tasks and procedures that will lead to their attainment.

12.2B A collection system agency can work towards a goal of operating safely by (1) managing to take actions that consistently promote safe operation by personnel and contractors, (2) establishing safety training programs for personnel, and (3) controlling the risks involved in the operation and maintenance of the collection system.

12.2C Excessive infiltration and exfiltration can be controlled by pressure grouting, slip lining or replacement of the leaking sewer lines. Other effective means include isolation of manhole and cleanout openings from surface water and the adoption and enforcement of sewer-use regulations prohibiting the discharge of storm or groundwater to the wastewater collection system.

12.2D Management can promote safety by personal use of safe practices, providing safety equipment and training and requiring adherence to safe work practices.

4.37

ANSWERS TO QUESTIONS IN LESSON 2

Answers to questions on page 328.

12.3A Overflows, spills, or raw wastewater by-passes must be reported to:

1. Regional Water Pollution Control Agency,
2. Local Health Department, and
3. Director of Public Works.

12.3B Clearwater's superintendent is responsible for planning and implementing maintenance, operation, training, and safety aspects of the section.

12.3C Items to be considered when summarizing a wastewater collection system include:

1. Total length of pipe and length of service lines and lines of different diameters,
2. Lift stations,
3. Condition of system, and
4. Problem areas in system.

Answers to questions on page 334.

12.3D Making the proper selection of personnel is important because capable workers are needed to operate and maintain a collection system safely and efficiently. Also, it is difficult to fire an employee and the agency will lose the investment made in the employment and training of the employee.

12.3E The potential positions of advancement for a Maintenance Person II, Wastewater Collection, include Foreman, Maintenance Supervisor I, or Construction Inspector.

12.3F Information that should be listed on "opportunities for employment notice" includes a brief description of the work to be performed, required qualifications, compensation, the selection process, where application forms can be obtained and the closing date for accepting applications.

12.3G During the first day of work, a new employee should be given all the information available in written and verbal form on the agency's policies and practices concerning compensation, benefits, attendance and other matters relating to employer-employee relations.

12.3H Adjustments that can be made to an employee's starting salary include: (1) longevity increases if the employee remains in the same position for a specified period and demonstrates concurrent improvement in work performance; and (2) cost of living increases.

Answers to questions on page 336

12.3I Collection system operators must be properly trained so they can effectively accomplish the tasks they are assigned. Effectiveness is indicated by the job being properly done quickly and safely.

12.3J Collection system operators can be trained on the job, by reading trade magazines and papers, by formal classroom training, by attending professional meetings and by home study.

12.3K Collection system operators should be given information that will:

1. Help with their continuing education (including safety),
2. Indicate to them the results they have achieved, and
3. Inform them of their importance to the organization.

12.3L The purpose of an annual meeting is to tell collection system operators what their year's efforts have produced.

12.3M The supervisor and the shop steward should try to cooperate and work together. The supervisor is management's link with the operators and the shop steward is the operator's link with management.

Answers to questions on page 337.

12.3N The basic elements of a superintendent's safety program include a safety policy statement (including disciplinary procedures), safety training and promotion, and accident investigation and reporting.

12.3O The safety policy statement should be prepared by the top management of the collection system agency since its purpose is to let employees know that the safety program has the full support of the agency and its management.

12.3P Management's responsibilities with regard to safety include:

1. Formulate a written safety policy,
2. Provide a safe work place,
3. Set achievable safety goals,
4. Provide adequate training, and
5. Delegate authority to ensure that the program is properly implemented.

12.3Q The collection system operators are the direct beneficiaries of a safety program. The operators share the responsibility to:

1. Observe prescribed work procedures with respect to personal safety and that of their co-workers,
2. Report any detected hazard to a manager immediately,
3. Report any minor accident that causes minor injuries,
4. Report near-miss accidents so that hazards can be removed or procedures changed to avoid problems in the future, and
5. Use all protective devices and safety equipment supplied to reduce the possibility of injury.

ANSWERS TO QUESTIONS IN LESSON 3

Answers to questions on page 340.

12.4A Tool and equipment requirements can be determined on the basis of size of collection system, work load, and objectives. Equipment selection should be based on the type or types of problems you want the equipment to solve.

12.4B Most modern collection system maintenance equipment has one particular function that it does most effectively.

12.4C The shotgun approach is not recommended because it is wasteful and unnecessary. Equipment should be used in those areas where it is most needed.

12.4D Equipment to implement a preventive maintenance program can be obtained through long- or short-term leasing or by contracting for a specialized job, rather than by outright purchase if not enough money is available.

12.4E Advantages to equipment leasing include:

1. Expensive equipment can be made available without an initial capital expenditure of considerable amount, and
2. Specialized equipment is made available to the agency, at a reasonable cost, to complete any one-time or seasonal programs.

12.4F Advantages of purchasing include:

1. Makes available standard equipment that is used continuously with a long life span for a reasonable price, and
2. Equipment is available when needed.

12.4G Contracting for work can be advantageous when an agency does not have sufficient qualified or qualifiable staff available to do a highly specialized job. Also the agency does not have to buy equipment that will not be used continuously.

Answers to questions on page 342.

12.4H Emergency crews should be provided with at least a 3/4-ton truck.

12.4I The following crews should be equipped with two-way radios or paging devices:

1. Emergency crew,
2. Rodding truck (one crew), and
3. Repair crew.

12.4J A truck with adequate capacity must be specified so the truck will not wear out before the high velocity cleaning equipment. A truck of marginal capacity could start developing brake problems, weakened springs, difficult road handling, and a loss of engine power after only a short period of use.

12.4K Truck-mounted units are preferable for units that are used on a full-time basis while trailer-mounted units are desirable for equipment used on a part-time basis because the truck pulling the trailer can be used for other purposes when the trailer-mounted unit is not in service.

12.4L Portable standby pumping units should be inspected and run at regular intervals to assure they will be in operating condition when an emergency does arise.

12.4M Major pieces of equipment needed for construction and repair include backhoe, dump truck, water truck, portable air compressor, and hoists.

12.4N Portable air compressors are used to operate jack hammers and tampers.

Answers to questions on page 344.

12.4O Air testing and joint sealing equipment is often used in conjunction with closed-circuit TV to inspect sewers. The equipment can be purchased separately or as packaged units mounted on a truck or trailer.

12.4P Seldom-used equipment such as large size sewer balls and portable emergency pumps must be stored at a location that is accessible to the crews when the equipment is needed.

12.4Q Three different types of electronic locators include:

1. Simple valve or lid locator,
2. Pipe locator, and
3. Ferret-type locator.

12.4R The two different types of plugs are air plugs and mechanical plugs.

12.4S Handmade taps should be discouraged because they often result in broken sewers, ill-fitting taps, and taps protruding into the sewer. These problems provide inviting areas for future root intrusion and for a person to use an excess of cement or grout in an effort to hide the whole crude job.

12.4T Taps protruding into sewers can be removed by use of an internal tap cutter that is manually pulled through the inside of a pipe. The protruding tap is cut off by use of a diamond-core drill.

12.4U Service lines can be placed under a major thoroughfare without disrupting traffic by boring a hole for the line under the thoroughfare.

Answers to questions on page 346.

12.4V Atmospheres that require testing before entering include confined spaces such as manholes and wet pits.

12.4W The three main items of concern when testing an atmosphere are:

1. Lack of oxygen,
2. An explosive condition, and
3. Toxic gases.

12.4X The atmosphere must be monitored continuously because the atmosphere can change suddenly.

12.4Y Fresh air can be introduced into confined spaces by the use of blowers.

12.4Z The different types of shoring include:

1. Hydraulic shoring,
2. Manual shoring consisting of screw jacks and wooden timbers,
3. Sheet shoring, and
4. Cylinder and shield shoring.

12.4AA Traffic control is often overlooked or underrated because crews occasionally get in a hurry and/or are careless.

12.4AB Collection system operators must wear protective clothing to protect themselves from unnecessary exposure to the hazards of their job. Protective clothing includes uniforms, safety shoes, rubber boots, rubber gloves, eye protection, hard hats, and safety harnesses.

Answers to questions on page 347.

12.4AC The main categories of microcomputer software (computer programs) that could be used by a collection system agency include:

1. Data base management,
2. Graphics,
3. Program development,
4. Spreadsheet analysis,
5. Telecommunications, and
6. Word processing.

12.4AD The essentials of an equipment inventory record include:

1. Type (high velocity cleaner),
2. Model year,
3. Date purchased,
4. Cost,
5. Description,
6. Manufacturer, and
7. Fuel type.

12.4AE Equipment should be replaced when it has reached the end of its useful life. Useful life can be defined as the time at which a piece of equipment ceases to perform its required work or when the cost of operating and maintaining the equipment is greater than the cost of operating and maintaining new equipment.

ANSWERS TO QUESTIONS IN LESSON 4

Answers to questions on page 351.

12.5A Services that should be available for vehicles and engine-driven special equipment in a maintenance yard include fuel, air, coolant and oil when needed.

12.5B Types of hazardous materials that could be stored in a maintenance area include toxic chemicals and flammable fuels.

12.5C Valuable shop tools and equipment should be inventoried and secured in an enclosed room with one person responsible for checking these items in and out. The entire shop area should be secured when authorized shop personnel are not in the immediate area and at the end of work shifts.

12.5D Landscaping of a collection system maintenance yard and office buildings is important to make the facilities pleasing to the public and visitors. Landscaping also will increase the satisfaction employees receive from working for the agency.

ANSWERS TO QUESTIONS IN LESSON 5

Answers to questions on page 353.

12.6A Maps of a wastewater collection system are important because they show where the system components are located, and the size of the collection system pipes. Maps enable maintenance operators to find specific components for repair and provide information that will eliminate guesswork concerning what tools and materials will be needed to complete a job.

12.6B Information required on wastewater collection system maps includes:

1. Locations,
2. Identifications,
3. Elevations,
4. Footage or distances,
5. Type of pipe,
6. Flow direction,
7. Force mains,
8. Soil conditions,
9. Property connected to collection system,
10. Inventory, and
11. Date.

12.6C All manholes should be identified by a specific number and/or letters and this identification should never change.

12.6D The essential elevations that should be shown on collection system maps include:

1. Flow lines or invert elevations at the site of each manhole,
2. Manhole rim elevations,
3. Depth of pipelines, and
4. Depth of house service line at property line.

12.6E Soil conditions are of great importance and a significant safety factor to future repair crews who have to dig in disturbed ground.

Answers to questions on page 362.

12.6F Assessor's maps contain the most detail.

12.6G Maps must be updated to maintain their usefulness and to reduce time-consuming and costly mistakes.

12.6H Maps can be kept up to date by:

1. Annual updating of all changes and corrections,
2. Recording changes when they occur,
3. Field operators (maintenance and inspectors) reporting all changes and discrepancies, and
4. Field checking existing maps with actual conditions in the field.

Answers to questions on page 362.

12.6I The advantages of using microfiche copies include a low reproduction cost, ease of handling, less storage space and they do not deteriorate with repeated handling.

12.6J Maps can be used as a maintenance record by showing:

1. Problem areas,
2. Maintenance activities, and
3. Proposed maintenance schedules.

12.6K Problem areas can be shown on a map by using colored pins or colored codes that indicate the type of problem (roots, grease) and frequency of the problems.

ANSWERS TO QUESTIONS IN LESSON 6

Answers to questions on page 366.

12.7A Current information no longer needed in a data base should be removed from the data base and stored in archives in case they may be needed in the future.

12.7B Data processing takes pieces of information independent in nature and unlimited in number (usually in the form of records) and produces useful information by arranging it into meaningful knowledge.

12.7C The quality of the information produced by computers is entirely dependent on the quality of data put into the computer and the software directing its processing.

12.7D Computer software can generate reports on scheduled, unscheduled, and projected work orders, plus service line, area and main line stoppages, and TV histories of sewer inspections.

Answers to questions on page 375.

12.7E Collection system operators account for their daily work activities of operating and maintaining collection systems by making daily work reports.

12.7F Types of work reports used by collection system agencies include:

1. Main sewer construction,
2. Main sewer maintenance,
3. Main sewer repair,
4. Structure maintenance,
5. Structure repair or abandonment,
6. Building sewer maintenance, and
7. Building sewer repair.

12.7G "Main sewer construction data" forms are used by a construction crew leader or an inspector when the construction is performed by a contractor.

12.7H The types of debris that can be found in sewers include egg shells or coffee grounds, grease or soap, paper or rags, grit (silt, sand, gravel), foreign objects, roots, mud, or solids.

12.7I Types of conditions that can be found in sewers include broken pipe, offset joints, infiltration, roots, sagging pipe and other defects.

Answers to questions on page 378.

12.7J Records are necessary because they provide:

1. A record of the past, and
2. A sound basis on which to plan the future.

12.7K Cost items that should be recorded include:

1. Labor,
2. Equipment,
3. Supplies, and
4. Services.

12.7L Records are very important when preparing a budget. Accurate records detailing last year's activities, costs, work load, growth and production (such as miles of lines cleaned) can be the best justification for next year's budget requests.

12.7M The best protection against legal action or liability claims is reliable records to verify that recommended procedures were followed and that no one was negligent in meeting their responsibility.

Answers to questions on page 383.

12.7N An individual's fact sheet should contain information on age, blood type, inoculations, dependents, and medical history for use in case of accident or serious injury. The file must be updated annually and include accidents, illnesses, training and new skills learned.

12.7O Information that should be included on a television survey history form includes date, video tape number and file location, observed conditions, footage from entrance of manhole to recorded observation, observed tap location, water level, root intrusion, grease and other debris, pipe conditions and any other conditions not listed.

12.7P Records must be retained in accordance with state and federal regulations. All records should be kept as long as they are thought to be useful or may be needed for defending claims for injuries or property damage submitted to an agency. An agency's legal counsel should be asked to provide guidance for retention of records.

Answers to questions on page 386.

12.7Q The superintendent of a collection system needs to have reports analyzing records on manpower, materials and equipment used to initiate actions to improve work efficiency. Reports on main sewer line stoppages are used to make adjustments to a collection system's preventive maintenance program. A superintendent will order the preparation of other reports as their need arises for preparing budget requests for manpower, materials, and equipment.

12.7R Computer-generated "service line reports" can provide a list of outstanding unscheduled work orders for service lines and a list of all service line unscheduled work orders completed within a given date range.

12.7S A "query retrieval system" is part of a computer software program which provides access to all the collection system records in a data base. The purpose of the system is to allow the user to create customized reports to meet the informational needs of a collection system program.

12.7T The monthly reports from each individual foreman should contain information regarding the daily production activity of each of the crews under each foreman. Activities involved may include balling, rodding, TV inspection, construction and repairs, or any other significant maintenance activities that are part of the organization's maintenance program.

Answers to questions on page 388.

12.7U Work directives given by superintendents and supervisors to operators include training in work performance and equipment operation, standard operating procedures and work orders.

12.7V Upon receipt of a "service request report," a supervisor immediately obtains any additional information needed for response to the request, makes a personal investigation if required, and gives directions to a service crew for responding to the service request.

12.7W If a service is not provided by the agency, the crew leader explains the agency's policy to the property owner and offers any appropriate suggestions on how the service might be obtained.

12.7X Duplicate or carbon copies of work orders are not needed when using computer systems because the original copies are retained in the computer for anyone who needs them.

12.7Y The most important aspects of effective administration or supervision for persons working with wastewater collection systems include:

1. Mapping,
2. Records,
3. Scheduling of maintenance work,
4. Staffing requirements,
5. Tool and equipment requirements,
6. Public relations,
7. Report writing, and
8. People.

ANSWERS TO QUESTIONS IN LESSON 7

Answers to questions on page 392.

12.8A Basic steps to follow when preparing a report include:

1. Organization, and
2. Composition.

12.8B A good outline helps to organize the report and present information in a logical sequence that is easily understood.

12.8C The intended readers of the report must be considered because different readers have different backgrounds and desire different information.

12.8D Drafts of reports help you to review the report, let others give you their reactions to it, and give you a chance to improve or "polish" the report.

Answers to questions on page 395.

12.9A Public relations are important because we are always in contact with the public. Our service should be sincere, courteous and understanding in spite of trying circumstances.

12.9B Responders to telephone complaints should try to make a good first impression. When answering the phone, identify yourself, be personable and sincere. Try to be understanding and sympathetic towards the caller's problem. Conclude the conversation with an acceptable solution and tell the caller when the problem will be solved. Follow up with a return call if necessary.

12.9C Positive personal contacts can be made by having a neat appearance, such as wearing a uniform or clean work clothes. A courteous and sincere attitude towards other people is very helpful. A knowledge of how to solve the problem is impressive.

12.9D Equality of service is important because if everyone is not given the same level of service, then everyone will want special service or favors beyond the responsibility of your agency. This extra service is time-consuming and costly to the taxpayer.

12.9E Everyone benefits from good public relations. The public will cooperate with your agency, understand what you are trying to do, and hopefully be satisfied with your services. Employees benefit from pleasant working conditions, recognition of their efforts, high morale and a satisfied public.

OBJECTIVE TEST

Chapter 12. ADMINISTRATION

Please mark the correct answers on an answer sheet as directed at the end of Chapter 1. There may be more than one correct answer to each multiple choice question.

TRUE-FALSE

1. Small collection systems may be operated by one collection system operator from memory.
   1. True
   2. False
2. Manhole numbers should be changed when additional manholes are installed so all manhole numbering follows a logical sequence.
   1. True
   2. False
3. Accurate and up-to-date maps can reduce costly and time-consuming mistakes.
   1. True
   2. False
4. Records of daily activities are of little use when legal problems develop.
   1. True
   2. False
5. Most collection systems are designed to be cleaned by preventive maintenance crews.
   1. True
   2. False

MULTIPLE CHOICE

6. Different types of maintenance programs include
   1. Emergency.
   2. Operation.
   3. Preventive.
   4. Public.
   5. Typical.
7. Records must not only be collected, but they MUST be
   1. Accurate.
   2. Complete.
   3. Computerized.
   4. Filed and used.
   5. Neat.
8. Reports on collection systems are needed to inform
   1. Employees.
   2. Management.
   3. Other agencies.
   4. Public.
   5. Typists.
9. Who benefits from good public relations?
   1. Employees
   2. Federal government
   3. Management
   4. Lawyers
   5. Public
10. Factors helpful for the PREPARATION of a good report include
    1. Composition.
    2. Consideration of intended reader.
    3. Copying what others wrote.
    4. Good literary style.
    5. Organization.
11. Good public relations include
    1. A courteous attitude.
    2. A neat appearance.
    3. Having someone do your public relations.
    4. Making a good "first" impression.
    5. Providing an equal level of service to everyone.
12. Public relations are important because we
    1. Like our jobs.
    2. Must deal with the public.
    3. Need lots of training.
    4. Want to finish our work in a hurry.
    5. Work for the public.
13. Safety equipment for field crews includes
    1. Air testing meters.
    2. Blowers.
    3. Chlorine testers.
    4. Protective clothing.
    5. Traffic control equipment.
14. Tool and equipment requirements depend on
    1. Effectiveness of salesmen.
    2. Objectives to be achieved.
    3. Size of collection system.
    4. Size of tool boxes and compartments.
    5. Type of equipment.
15. Sources of training for crew members include
    1. Elementary school.
    2. Home study courses.
    3. On-the-job.
    4. Professional journals and papers.
    5. Short schools at conferences.
16. Size of crew depends on
    1. Need to direct traffic.
    2. Number of qualifiable operators available.
    3. Safety regulations.
    4. Type of activity.
    5. Type of equipment.
17. Staffing requirements should be based on
    1. Comparisons with other cities.
    2. Objectives.
    3. Published guidelines.
    4. Size and condition of collection system.
    5. Work load.

18. Factors essential for planning a maintenance schedule include

    1. Desired effectiveness of schedule.
    2. Knowledge of collection system.
    3. Knowledge of maintenance procedures and equipment.
    4. Objective of activities.
    5. Timing of activities.

19. Types of records needed to operate and maintain wastewater collection systems include

    1. Costs.
    2. Equipment maintenance.
    3. Inventory.
    4. Personnel.
    5. Production.

20. A telephone log of a complaint should contain

    1. Name of person assigned to investigate.
    2. Nature of complaint.
    3. Sex of caller.
    4. Time call was received.
    5. Tone of caller's voice.

21. A foreman's monthly report should include

    1. Last time supervisor read report.
    2. Number of complaints received and investigated.
    3. Number of monthly reports prepared.
    4. Number of stoppages cleared.
    5. Production of each crew.

22. Information required on maps includes

    1. Date map was prepared and revision dates.
    2. Elevations.
    3. Flow direction.
    4. North arrow.
    5. Type of pipe.

23. Maps are needed to

    1. Plan activities for crews.
    2. Prepare good reports.
    3. Prepare maintenance programs.
    4. Prevent legal claims.
    5. Show locations of facilities.

24. Maps must be kept up-to-date so

    1. Costly and time-consuming mistakes will be reduced.
    2. Crews will know exact field conditions.
    3. Location of underground facility can be quickly determined.
    4. Paperwork won't pile up.
    5. The assessor will not get lost.

25. In general, records fill two basic needs, (select the best answers)

    1. They record how much money was budgeted and how much was spent.
    2. They record the past and provide a sound basis on which to plan the future.
    3. They record what was done and when it was done.
    4. They record where we've been and how we got where we are today.
    5. They record who did what and why it was done.

26. Collection system agency personnel requirements are influenced by

    1. Age of operators.
    2. Age of system.
    3. Climate.
    4. Size of population served.
    5. Topography.

27. Management information systems can

    1. Allocate resources for various activities.
    2. Decide which jobs should be done first.
    3. Help improve scheduling of jobs.
    4. Simplify the job of work scheduling.
    5. Track work force activity.

28. A microcomputer and its software can be applied to a management information system to

    1. Create a data base.
    2. Determine what data is needed.
    3. Input data into a data base.
    4. Prepare desired information reports.
    5. Produce written directives.

29. Who is legally responsible for ensuring that safe work procedures are followed?

    1. Operators
    2. Management
    3. Personnel office
    4. Shop steward
    5. Superintendent

30. Steps in the hiring process include

    1. Checking references.
    2. Checking the grapevine.
    3. Interviewing applicants.
    4. Preparing a job announcement.
    5. Updating operators' personnel files.

31. Personnel files usually contain information about an employee's

    1. Educational background.
    2. Family.
    3. Political activities.
    4. Religious preferences.
    5. Work history.

32. The responsibilities of a supervisor include

    1. Calculate personnel requirements for operation and maintenance.
    2. Discipline operators who violate safety policies.
    3. Field check all system maps for accuracy.
    4. Keep the shop steward away from the operators.
    5. Monitor the work performance of assigned crews.

33. Which of the following pre-employment questions may be asked of an applicant?

    1. Are you married?
    2. Are you presently employed?
    3. Have you ever belonged to a union?
    4. May we contact your current employer?
    5. What is your birthdate?

REVIEW QUESTIONS

34. Collection system operators should never attempt to install, troubleshoot, maintain, repair or replace electrical equipment panels, controls, wiring or circuits unless

    1. A manhole is overflowing down a street.
    2. A pump is plugged.
    3. A wet well is overflowing and flooding a lift station.
    4. You are receiving lots of odor complaints.
    5. You know what you are doing, are qualified, and are authorized.

35. Safety precautions that must be taken BEFORE entry into a manhole include:

    1. Have two people standing by topside.
    2. Provide adequate ventilation.
    3. Put on harness.
    4. Route traffic around manhole.
    5. Test atmosphere in manhole.

36. When handling and storing lubricants, special precautions include

    1. Keeping all lids of lubricant containers tightly closed.
    2. Keeping open flames away from stored lubricants.
    3. Making sure lubricant storage areas do not create a fire hazard.
    4. Posting "No Smoking" signs outside buildings.
    5. Wiping up all spills of lubricants.

END OF OBJECTIVE TEST

CHAPTER 13

ORGANIZATION FOR SYSTEM OPERATION AND MAINTENANCE

by

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TABLE OF CONTENTS

Chapter 13. Organization for System Operation and Maintenance

Page

OBJECTIVES 408

LESSON 1

13.0 Need for Organization 409

13.1 Organizational Principles 409

13.11 Knowledge of Work 409

13.12 Personnel and Equipment 409

13.13 Unitization 409

13.14 Line of Authority 409

13.15 Responsibility 410

13.16 Accountability 410

13.17 Management 410

13.2 Organization of Personnel 411

13.21 Work Activities 411

13.22 Occupational Titles 411

13.23 Assignment of Personnel 412

13.24 Types of Crews 412

LESSON 2

13.3 Clearwater Collection System Division Organization 422

13.31 Service Request and Preventive Maintenance Section 422

13.311 Responding to Request for Stoppage Removals 423

13.312 Flooding Caused by Stoppages 423

13.313 Other Requests 425

13.314 Service Crew Functions 425

13.315 Preventive Maintenance 426

13.316 Preventive Maintenance Crew Functions 426

13.317 Equipment 427

13.318 Training Crews 429

13.32 Repair and Replacement Section 429

13.321 Repairs 432

13.322 New Construction 432

13.323 Equipment 432

LESSON 3

13.33 Mechanical Maintenance (and Equipment Servicing) Section 435
    13.331 Scope of Work 437
    13.332 Lift Station Failures 437
    13.333 Preventive Maintenance Schedule 437
    13.334 Equipment 438
13.34 Inspection and Investigation Section 438
    13.341 TV Inspection 438
    13.342 Infiltration/Inflow Investigation 438
    13.343 Manhole Inspections 438
    13.344 Industrial Waste Inspections 440
    13.345 Inspection Equipment 440
    13.346 Additional Essential Equipment 441
13.35 Staff 442
    13.351 Superintendent 442
    13.352 Assistant Superintendent 442
    13.353 Maintenance Supervisors 442
    13.354 Support Services and Personnel 442

LESSON 4

13.4 Safety Considerations 445
13.5 Reorganization 446
13.6 Scheduling Maintenance 446
    13.61 Types of Maintenance 446
        13.611 Emergency Maintenance 446
        13.612 Preventive Maintenance 446
    13.62 Basic Aspects of Scheduling 447
        13.621 Knowledge 447
        13.622 Timing 447
        13.623 Adjusting Schedules 447
    13.63 Examples of Scheduling 448
        13.631 Sacramento County, California 448
        13.632 Santa Clara County, California 448
13.7 General Performance Indicators 452
13.8 Additional Reading 452
SUGGESTED ANSWERS 454
OBJECTIVE TEST 458

OBJECTIVES

Chapter 13. ORGANIZATION FOR SYSTEM OPERATION AND MAINTENANCE

After completion of Chapter 13 you should be able to do the following:

1. Organize an agency to operate and maintain a wastewater collection system,
2. Identify functions and work activities of essential units within an agency,
3. Staff and equip essential units within an agency,
4. Develop priority lists for job assignments for units within an agency,
5. Schedule the collection system activities of an agency, and
6. Evaluate performance of collection system and agency.

Chapter 13. ORGANIZATION FOR SYSTEM OPERATION AND MAINTENANCE

(Lesson 1 of 4 Lessons)

13.0 NEED FOR ORGANIZATION

In the preceding Chapter 12 on administration you were introduced to the personnel, equipment, facilities and information systems used for the operation and maintenance of a wastewater collection system. These separate elements of administration need to be organized into a business structure. Such organization begins with identification of the special functions or each element and its relationship to the operation and maintenance of a collection system.

Collection system operators need to be organized into crews with individuals and equipment capable of performing assigned tasks. It will be necessary to establish a line of authority and to assign responsibility and accountability for operation and maintenance of the collection system. A collection system division may have good operators and equipment, but if they are not well organized, the system will not be operated and maintained efficiently.

13.1 ORGANIZATIONAL PRINCIPLES

As we consider the organization of a division for the operation and maintenance of a wastewater collection system, we need to be guided by organizational principles. These principles are discussed in the following paragraphs.

13.11 Knowledge of Work

Any organization is built upon a precise knowledge of the work required to accomplish its goals and objectives. With this knowledge, work using the same classes of personnel and types of equipment can be grouped together for the purpose of efficient assignment. To develop a knowledge of an organization's work, begin by preparing a clear statement of its mission, followed by its goals and objectives. Then you can identify the separate tasks needed to reach the objectives and goals, and prepare a detailed listing of the types of work involved in each task.

13.12 Personnel and Equipment

After you have prepared a detailed list of work to be performed by your organization and have grouped tasks by similarities, consider the type of personnel and equipment needed to perform the work. The amount of personnel and equipment needed will be determined by an estimate of the amount of work to be performed.

The type of personnel and equipment should be standardized to the greatest extent possible to avoid the need for special and expensive personnel and equipment. You can consult with superintendents and supervisors of other collection system agencies to determine the occupational descriptions and specifications of equipment that have been standardized for operation and maintenance of wastewater collection systems. The publications listed as Items 4 and 5 in Section 12.9, Chapter 12, "Additional Reading", provide good occupational titles and job descriptions for standard collection system personnel. Also Chapters 5, 6, and 7 of this manual have described standard personnel titles and equipment used for operation and maintenance of collection systems.

13.13 Unitization

Most of the work required for the operation and maintenance of a collection system is performed by several persons working together as a unit for efficiency and safety purposes. These units are generally called crews. Members of a crew must perform their work as a team and, to be efficient, they must be familiar with each other and with their work. Therefore, crew members should work together performing the same type of work for an extended period of time. Rotation of personnel to different crews or types of work should only be done as a deliberate effort to improve the efficiency of the organization or advance the career of a capable and worthy person.

13.14 Line of Authority

In most organizations authority is essentially power—power to decide how the resources of the organization will be utilized to achieve its mission. This power usually is vested in (held by) the owner or highest official of the company, agency, or organization. As an organization increases in size, it becomes necessary to give some of this power to other staff members because no single person would be able to effectively make all decisions, supervise all work, and respond to all daily concerns that arise.

When power is delegated to others, it is usually limited to specific areas of responsibility such as personnel, financial operations, or collection system operation and maintenance. More limited powers may then be further delegated, for example, to individuals who supervise daily work activities or specific crews of operators within a section of the organization.

The overall purpose of delegating authority in this way is to allow decisions to be made and actions to be taken at the lowest practical level within the organization. The effect of this is to free upper management from activities that would otherwise consume so much of their time that they would be unable to meet their broader responsibilities for planning and managing.

A second outcome of delegating authority is that decisions about daily operations can be made by those who are most familiar with the situation and most directly affected by the decisions. This usually means a more efficient operation.

It is common practice to visually represent the delegation of authority with an organization chart such as Table 13.7 on page 443. The lines connecting positions trace the line of authority that has been delegated by the superintendent to an assistant, who has then delegated some of the authority to four sections heads, and so on down the line. Table 13.7 makes it clear that the Mechanical Maintenance Section Supervisor I gets authority from and reports directly to the Assistant Superintendent, and not to the head of Personnel or Engineering.

One of the principles on which decisions about delegation of authority are made is the principle of span or control. It is widely believed that a person can effectively manage only about five people. Unique situations within an organization will cause frequent exceptions to this rule of thumb but in general, a larger span of control dilutes the actual amount of control a supervisor can realistically exercise over each subordinate.

13.15 Responsibility

Whenever authority is delegated to someone else there must be a clear understanding by both parties about exactly what authority is being given. That is to say, it must be clear to both parties precisely what the power enables the recipient to do. When authority is given, it is accompanied by responsibility to produce certain specified results. Authority and responsibility cannot be separated; to do so is to invite failure.

As an example, assume you make a supervisor responsible for ensuring that five operators within the span of control observe prescribed safety precautions. One operator repeatedly neglects safety precautions and is reprimanded by the supervisor using the established progressive discipline policy of the agency. An accident occurs that is directly attributable to an unsafe practice by this same operator and the supervisor puts the operator on unpaid administrative leave for one day. You overrule the supervisor's decision because "there's work to be done" and "everyone makes a mistake now and then."

By overruling the supervisor, you have taken back the authority you had delegated. Without this authority, responsibilities for observance of safe practices cannot be exercised and the subordinate cannot be made to comply. The supervisor has no power and is likely to fail to meet responsibilities in this area.

13.16 Accountability

As we have seen, when a person is given authority it comes with specific responsibilities to produce certain results. These responsibilities are usually spelled out in a job description for each position within the organization. But having given some powers to a person, how does the organization know whether the person is meeting assigned responsibilities? The organization must develop some system of accountability as part of its management information system. It must establish performance standards and develop a way to measure each employee's performance. When the level of performance is exceptionally good, the employee (being accountable for successfully meeting or exceeding responsibilities) deserves reward or recognition for it. When performance does not fulfill assigned responsibilities, the employee (being accountable for the employee's actions) can legitimately be held responsible and denied reward or recognition, or may be penalized in some way.

To hold persons accountable for their actions, three factors must *ALL* be present:

1. The individuals must know what they are supposed to do. This knowledge could be derived from a job description, an operations manual, or direct instruction.
2. The individuals must know how to accomplish assigned tasks. Minimum skill levels for hiring purposes, training programs, and direct instruction can accomplish this.
3. The individuals must have control of the factors that regulate what they are doing.

To see the importance of the third factor, let's return to the example of the supervisor whose subordinate violated safety precautions. The supervisor knew what had to be done (ensure safety compliance); knew how to do it (used established progressive discipline procedures); but lacked the authority that would enable the correct action to be taken (you overruled the supervisor). So when it comes time to hold the supervisor accountable for ensuring compliance with safety regulations, you will not legitimately be able to penalize the supervisor for failing to meet this responsibility because control of all the factors affecting the supervisor's actions was not permitted.

Accountability is a complex issue but one that it is essential to understand if an organization is to operate efficiently. There are a large number of associated legal issues, particularly if a union contract governs employee activities, that must be considered with respect to rewards, punishment, performance evaluations, work standards, and operating procedures. It is good practice to check with the staff of your legal department on such issues and to familiarize yourself thoroughly with the established policies and procedures of your agency.

CONTROL
DIRECT
PLAN
ORGANIZE
STAFF

13.17 Management

The proper management of a wastewater collection system requires the manager or supervisor to plan, organize, staff, direct and control the activities of the agency. Planning consists of determining the goals, policies, procedures and other elements to achieve the goals and objectives of the agency. Planning requires the supervisor to collect and analyze data, consider alternatives and then make decisions. Planning must be done before the other managing functions.

Organizing means that the supervisor decides who does what work and delegates authority to the appropriate operators. Employment or staffing is the recruiting of new operators and staff and determining if there are enough qualified operators and staff to fill available positions. Employment also includes selection, training, promoting, evaluating performance and providing opportunities for advancement for operators and staff in the agency.

Directing includes the guiding, teaching, motivating and supervising of operators and staff. Direction includes issuing orders and instructions so that jobs are performed safely and are properly completed. Operators and staff must be stimulated to perform their tasks efficiently.

Controlling involves being sure that essential activities are performed to be certain that objectives are achieved as planned. Controlling means being sure that progress is being made towards objectives and taking corrective action as necessary.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 454.

13.1A How can the type of personnel and equipment needed to perform the work of an organization be determined?

13.1B Why should crew members work together and perform the same type of work for an extended period of time?

13.1C What are the two main effects of delegating authority?

13.1D What three factors govern whether an employee can be held accountable for meeting his or her assigned responsibilities?

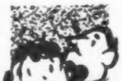
13.2 ORGANIZATION OF PERSONNEL

In Chapter 12 you were introduced to a superintendent who had been employed by the City of Clearwater, USA, and given the responsibility of reorganizing the division that operated and maintained the city's wastewater collection system. We will now consider how the superintendent used organizational principles in reorganizing the division to move toward accomplishing the goals and objectives set forth in the operating plan described in Section 12.2 of Chapter 12 (pages 321-323).

13.21 Work Activities

Let us review the work activities the superintendent identified for the collection system division and listed in (Tables 12.1 and 12.2, page 327). The superintendent used this list to prepare the following work groupings and the related major tasks:

- Service Requests
    - Main Sewer Stoppages
    - Building Sewer Stoppages
- Preventive Maintenance
    - Balling and Flushing
    - High Velocity Cleaning
    - Power Rodding
    - Bucketing
    - Chemical Treatment
- Repair and Replacement
    - Main Sewers
    - Joint Sealing
    - Sewer Lining
    - Manholes
    - Building Sewers
- Mechanical Maintenance
    - Lift Station Inspections and Servicing
    - Lift Station Repairs
- Inspections and Investigations
    - Manholes
    - TV Main Sewers
    - Infiltration/Inflow Investigations
    - Industrial Waste Inspections
- Indirect
    - Equipment Servicing
    - Building and Grounds Maintenance
    - Work for Other Departments
    - Training
    - Leave and Holidays



13.22 Occupational Titles

The next organizational step taken by the superintendent was to determine what types of collection system operators already worked in the division and what additional staff would have to be employed to perform the planned work activities. The superintendent used previous experience, consultations with other superintendents and the publications on manpower requirements for wastewater collection systems (listed as Items 4 and 5 in Section 12.10 of Chapter 12) to standardize the occupational descriptions and titles of most collection system personnel.

The following is a listing of the most common occupational titles for which job descriptions are readily available:

Superintendent
Assistant Superintendent
Maintenance Supervisor II
Maintenance Supervisor I
Equipment Supervisor
TV Technician II
TV Technician I
Foreman
Maintenance Man II
Maintenance Man I
Mason II
Mason I
Maintenance Equipment Operator
Construction Equipment Operator
Automotive Equipment Operator
Laborer
Maintenance Mechanic II
Maintenance Mechanic I
Maintenance Mechanic Helper
Electrician
Computer Operator
Computer Programmer
Clerk Typist
Stock Clerk
Dispatcher

The superintendent knew that all the different types of personnel would not be needed to operate and maintain the collection system for the medium size population of 180,000 in the City of Clearwater. The superintendent also knew that the duties of some operators would have to be combined and the superintendent planned to compensate those operators with the salary appropriate for the highest classification describing some of their duties. For example, the superintendent planned to use TV Technicians to operate the TV equipment when inspecting main sewers and also use them to make visual inspections of the system's manholes. A Maintenance Man II would also serve as a crew leader and equipment operator. In each of these cases of combined job levels, the operator would be paid at the rate for the higher job classification.

13.23 Assignment of Personnel

The superintendent used the list of work activities, their annual staff day requirements listed in Tables 12.1 and 12.2 (page 327) and the appropriate occupational titles to make a logical assignment of existing and new personnel. The assignments are shown first by work activities in Table 13.1 and by occupational titles in Table 13.2.

Table 13.1 begins to show the units of personnel that will be working together as a team for efficiency and safety purposes. The total of "Annual Staff-Day Amount" for each work activity equals the estimated time listed in Tables 12.1 and 12.2 and total of each "Annual Staff Days Percent" shows the percentage of personnel needed for a specific work activity. Table 13.2, on the other hand, shows the different work activities assigned to each operator. The superintendent made a conscious effort to maintain a continuity of crew members, minimize the number of different work activities and provide work experiences for career advancement. The last two listed in Table 13.2 show that the entire 260 (5 days/week x 52 weeks) staff days of time for each employee has been assigned an activity and the percent of the employee's time that each specific activity occupies.

You may want to use your own experience and ideas to assign different personnel to the work activities listed in Tables 12.1 and 12.2 to produce what you think will be a more efficient use of personnel. The superintendent also plans to modify assignments as more experience is gained in the operation and maintenance of Clearwater's wastewater collection system and as conditions vary from those anticipated at the time the assignments were made.

13.24 Types of Crews

The types of crews, their individual makeup and the number of each type crew required can be as varied as the size, scope of maintenance activities, program objectives, geographic locations, and management philosophies of the many collection system maintenance organizations in existence today. We do not believe it is practical to offer any kind of formula that would suggest that, for a collection system of a particular size with certain specific existing problems, you will require a given number of operators or of any particular type of maintenance crew.

Throughout this manual, you have been given specific information about the types of crews that will be discussed in this chapter. Detailed instructions as to the daily functions and activities have been thoroughly covered in the other chapters.

This discussion will be confined to more general aspects of crew staffing and jobs performed by the different types of crews. Proposed is the most practical size, based on experience of others, for each particular type of crew. Also, again based on experience, suggestions will be offered about how to use these crews most efficiently. The size of the collection system being maintained will have an influence on how each particular type of crew can be used. In large collection systems, crews tend to become more specialized and limited to performing their particular maintenance activity on a somewhat permanent or continuing basis. Smaller systems will find it more efficient to vary the activities of the crews at their disposal.

As mentioned earlier, it is usually desirable to allow crew members to work together for a period of time so that they get to know each other and become thoroughly familiar with their work assignments. Other factors that should be considered when assigning operators to crews are:

1. Maintaining continuity of members in a crew,
2. Minimizing the number of different work activities of each crew,
3. Providing work experiences for career advancement, and
4. Developing the skills of operators who could fill in on a crew in case of illness.

You will find it necessary to weigh the importance of each of these factors in deciding crew assignments. As your needs change, you may find it crucial at some point to rotate a few operators through various crews so that they are better prepared to fill in when needed. At another time it may be more important to keep crew assignments unchanged until the newly hired operators can become acquainted with the system and until you have had a chance to evaluate their strengths and weaknesses.

EMERGENCY SERVICE REQUEST CREW. Clearing stoppages is the job of an emergency crew. This is probably the basic crew in any maintenance organization. Certainly, it will be the first crew to become necessary. In smaller systems, it may be the only crew available. Two operators should be adequate except when it becomes necessary to enter a manhole. Three operators are required for this hazardous

TABLE 13.1 ASSIGNMENT OF PERSONNEL LISTED BY WORK ACTIVITY

Work Activity	No.	Personnel Occupational Title		Annual Staff Days	
				Amount	Percent
Service Requests					
Main Sewer Stoppages	L1	Maintenance Man	II	61.4	24
	L2	Maintenance Man	I	61.4	24
			Totals	122.8	48
Building Sewer Stoppages	L3	Maintenance Man	II	132.3	51
	L4	Maintenance Man	I	132.3	51
			Totals	264.6	102
Preventive Maintenance					
Balling and Flushing	L5	Maintenance Man	II	148.2	57
	L6	Maintenance Man	I	148.2	57
	L7	Maintenance Man	I	148.2	57
			Totals	444.6	171
High Velocity Cleaning	L8	Maintenance Man	II	192.4	74
	L9	Maintenance Man	I	192.4	74
	L3	Maintenance Man	II	31.4	12
	L4	Maintenance Man	I	31.4	12
			Totals	447.6	172
Power Rodding	L1	Maintenance Man	II	137.5	53
	L2	Maintenance Man	I	137.5	53
			Totals	275.0	106
Bucketing	L10	Maintenance Man	II	90.8	35
	L11	Maintenance Man	I	90.8	35
	L12	Maintenance Man	I	90.8	35
	L13	Laborer		90.8	35
			Totals	363.2	140
Chemical Treatment	L10	Maintenance Man	II	33.0	13
	L11	Maintenance Man	I	33.0	13
	L12	Maintenance Man	I	33.0	13
			Totals	99.0	39
Repair and Replacement					
Main Sewers	L14	Maintenance Man	II	185.2	71
	L15	Maintenance Man	I	185.2	71
	L16	Maintenance Man	I	185.2	71
	L17	Laborer		185.2	71
			Totals	740.8	284
Joint Sealing	L18	TV Technician	II	9.3	4
	L19	TV Technician	I	9.3	4
	L16	Maintenance Man	I	9.3	4
	L17	Laborer		9.3	4
			Totals	37.2	16
Sewer Lining	L5	Maintenance Man	II	12.4	5
	L6	Maintenance Man	I	12.4	5
	L7	Maintenance Man	I	12.4	5
	L13	Laborer		12.4	5
			Totals	49.6	20
Manholes	L10	Maintenance Man	II	65.8	25
	L11	Maintenance Man	I	65.8	25
	L12	Maintenance Man	I	65.8	25
			Totals	197.4	75
Building Sewers	L20	Maintenance Man	II	114.0	44
	L21	Maintenance Man	I	114.0	44
	L22	Maintenance Man	I	114.0	44
			Totals	342.0	132

TABLE 13.1 ASSIGNMENT OF PERSONNEL LISTED BY WORK ACTIVITY (Cont'd)

Work Activity	No.	Personnel Occupational Title		Annual Staff Days	
				Amount	Percent
Mechanical Maintenance					
Lift Station Inspections and Servicing	L23	Maintenance Mechanic	II	69.3	27
	L24	Maintenance Mechanic	I	69.3	27
	L25	Electrician		69.3	27
			Totals	207.9	81
Lift Station Repairs	L23	Maintenance Mechanic	II	40.0	15
	L24	Maintenance Mechanic	I	40.0	15
	L25	Electrician		40.0	15
			Totals	120.0	45
Inspections and Investigations					
Manholes	L20	Maintenance Man	II	71.0	27
	L21	Maintenance Man	I	71.0	27
	L18	TV Technician	II	40.0	15
	L19	TV Technician	I	40.0	15
	L5	Maintenance Man	II	12.4	5
	L7	Maintenance Man	I	12.4	5
			Totals	246.8	94
TV Main Sewers	L18	TV Technician	II	37.1	14
	L19	TV Technician	I	37.1	14
	L3	Maintenance Man	II	37.1	14
	L4	Maintenance Man	I	37.1	14
	L18	TV Technician	II	37.1	14
	L19	TV Technician	I	37.1	14
	L5	Maintenance Man	II	37.1	14
	L6	Maintenance Man	I	37.1	14
	L18	TV Technician	II	74.1	28
	L19	TV Technician	I	74.1	28
	L22	Maintenance Man	I	74.1	28
	L13	Laborer		74.1	28
			Totals	593.2	224
Infiltration/ Inflow Investigations	L1	Maintenance Man	II	16.5	6
	L7	Maintenance Man	I	16.5	6
	L15	Maintenance Man	I	16.5	6
	L18	TV Technician	II	12.4	5
	L19	TV Technician	I	12.4	5
	L7	Maintenance Man	I	12.4	5
	L22	Maintenance Man	I	12.4	5
			Totals	99.1	38
Industrial Waste Inspections	L8	Maintenance Man	II	17.2	7
	L9	Maintenance Man	I	17.2	7
	L10	Maintenance Man	II	17.2	7
	L11	Maintenance Man	I	17.2	7
	L20	Maintenance Man	II	17.2	7
	L21	Maintenance Man	I	17.2	7
			Totals	103.2	42

TABLE 13.1 ASSIGNMENT OF PERSONNEL LISTED BY WORK ACTIVITY (Cont'd)

Work Activity	No.	Personnel Occupational Title		Annual Staff Days Amount	Annual Staff Days Percent
Indirect					
Equipment Servicing	L18	TV Technician	II	5.9	2
	L19	TV Technician	I	5.9	2
	L23	Maintenance Mechanic	II	106.5	41
	L24	Maintenance Mechanic	I	106.5	41
	L25	Electrician		106.5	41
			Totals	331.3	127
Building and Grounds Maintenance	L1	Maintenance Man	II	0.4	-
	L2	Maintenance Man	I	16.9	6
	L3	Maintenance Man	II	15.0	6
	L4	Maintenance Man	I	15.0	6
	L5	Maintenance Man	II	5.7	2
	L6	Maintenance Man	I	18.1	7
	L7	Maintenance Man	I	13.9	5
	L8	Maintenance Man	II	6.2	2
	L9	Maintenance Man	I	6.2	2
	L10	Maintenance Man	II	9.0	3
	L11	Maintenance Man	I	9.0	3
	L12	Maintenance Man	I	12.9	5
	L13	Laborer		18.2	7
	L15	Maintenance Man	I	14.1	5
	L16	Maintenance Man	I	21.3	8
	L17	Laborer		21.3	8
	L20	Maintenance Man	II	13.6	5
	L21	Maintenance Man	I	13.6	5
	L22	Maintenance Man	I	15.3	6
			Totals	245.7	91
Work for Other Departments	L12	Maintenance Man	I	13.3	5
	L13	Laborer		20.3	8
	L14	Maintenance Man	II	30.6	12
			Totals	64.2	25
Training		All Line Personnel		325.0	125
Leave and Holidays		All Line Personnel		780.0	300
		Grand	Totals	6500.0	2500

TABLE 13.2 ASSIGNMENT OF PERSONNEL LISTED BY PERSONNEL DESIGNATION

No.	Occupational Title	Work Activity		Annual Staff Days Amount	Annual Staff Days Percent
L1	Maintenance Man II	Main Sewer Stoppages		61.4	24
		Power Rodding		137.5	53
		Infiltration/Inflow In'vst		16.5	6
		Buildings and Grounds		0.4	-
		Training		13.0	5
		Leave and Holidays		31.2	12
			Totals	260.0	100
L2	Maintenance Man I	Main Sewer Stoppages		61.4	24
		Power Rodding		137.5	53
		Buildings and Grounds		16.9	6
		Training		13.0	5
		Leave and Holidays		31.2	12
			Totals	260.0	100

TABLE 13.2 ASSIGNMENT OF PERSONNEL LISTED BY PERSONNEL DESIGNATION (Cont'd)

No.	Occupational Title	Work Activity	Annual Staff Days	
			Amount	Percent
L3	Maintenance Man II	Building Sewer Stoppages	132.3	51
		High Velocity Cleaning	31.4	12
		TV Main Sewers	37.1	14
		Buildings and Grounds	15.0	6
		Training	13.0	5
		Leave and Holidays	31.2	12
		Totals	260.0	100
L4	Maintenance Man I	Building Sewer Stoppages	132.3	51
		High Velocity Cleaning	31.4	12
		TV Main Sewers	37.1	14
		Buildings and Grounds	15.0	6
		Training	13.0	5
		Leave and Holidays	31.2	12
		Totals	260.0	100
L5	Maintenance Man II	Balling and Flushing	148.2	57
		Sewer Lining	12.4	5
		TV Main Sewers	37.1	14
		Manhole Inspections	12.4	5
		Buildings and Grounds	5.7	2
		Training	13.0	5
		Leave and Holidays	31.2	12
		Totals	260.0	100
L6	Maintenance Man I	Balling and Flushing	148.2	57
		Sewer Lining	12.4	5
		TV Main Sewer	37.1	14
		Buildings and Grounds	18.1	7
		Training	13.0	5
		Leave and Holidays	31.2	12
		Totals	260.0	100
L7	Maintenance Man I	Balling and Flushing	148.2	57
		Sewer Lining	12.4	5
		Manhole Inspections	12.4	5
		Infiltration/Inflow In'vst	28.9	11
		Buildings and Grounds	13.9	5
		Training	13.0	5
		Leave and Holidays	31.2	12
		Totals	260.0	100
L8	Maintenance Man II	High Velocity Cleaning	192.4	74
		Industrial Waste Insp'tns	17.2	7
		Buildings and Grounds	6.2	2
		Training	13.0	5
		Leave and Holidays	31.2	12
		Totals	260.0	100
L9	Maintenance Man I	High Velocity Cleaning	192.4	74
		Industrial Waste Insp'tns	17.2	7
		Buildings and Grounds	6.2	2
		Training	13.0	5
		Leave and Holidays	31.2	12
		Totals	260.0	100
L10	Maintenance Man II	Bucketing	90.8	35
		Chemical Treatment	33.0	13
		Manhole Repairs	65.8	25
		Industrial Waste Insp'tns	17.2	7
		Buildings and Grounds	9.0	3
		Training	13.0	5
		Leave and Holidays	31.2	12
		Totals	260.0	100

TABLE 13.2 ASSIGNMENT OF PERSONNEL LISTED BY PERSONNEL DESIGNATION (Cont'd)

No.	Occupational Title	Work Activity	Annual Staff Days Amount	Annual Staff Days Percent
L11	Maintenance Man I	Bucketing	90.8	35
		Chemical Treatment	33.0	13
		Manhole Repairs	65.8	25
		Industrial Waste Insp'tns	17.2	7
		Buildings and Grounds	9.0	3
		Training	13.0	5
		Leave and Holidays	31.2	12
		Totals	260.0	100
L12	Maintenance Man I	Bucketing	90.8	35
		Chemical Treatment	33.0	13
		Manhole Repairs	65.8	25
		Buildings and Grounds	12.9	5
		Work for Other Departments	13.3	5
		Training	13.0	5
		Leave and Holidays	31.2	12
		Totals	260.0	100
L13	Laborer	Bucketing	90.8	35
		Sewer Lining	12.4	5
		TV Sewer Mains	74.1	28
		Buildings and Grounds	18.2	7
		Work for Other Departments	20.3	8
		Training	13.0	5
		Leave and Holidays	31.2	12
		Totals	260.0	100
L14	Maintenance Man II	Repair and Replace Mains	185.2	71
		Work for Other Departments	30.6	12
		Training	13.0	5
		Leave and Holidays	31.2	12
		Totals	260.0	100
L15	Maintenance Man I	Repair and Replace Mains	185.2	71
		Infiltration/Inflow In'vst	16.5	6
		Buildings and Grounds	14.1	6
		Training	13.0	5
		Leave and Holidays	31.2	12
		Totals	260.0	100
L16	Maintenance Man I	Repair and Replace Mains	185.2	71
		Joint Sealing	9.3	4
		Buildings and Grounds	21.3	8
		Training	13.0	5
		Leave and Holidays	31.2	12
		Totals	260.0	100
L17	Laborer	Repair and Replace Mains	185.2	71
		Joint Sealing	9.3	4
		Buildings and Grounds	21.3	8
		Training	13.0	5
		Leave and Holidays	31.2	12
		Totals	260.0	100
L18	TV Technician II	TV Main Sewers	148.2	57
		Joint Sealing	9.3	4
		Manhole Inspections	40.0	15
		Infiltration/Inflow In'vst	12.4	5
		Equipment Servicing	5.9	2
		Training	13.0	5
		Leave and Holidays	31.2	12
		Totals	260.0	100

TABLE 13.2 ASSIGNMENT OF PERSONNEL LISTED BY PERSONNEL DESIGNATION (Cont'd)

No.	Occupational Title	Work Activity	Annual Staff Days	
			Amount	Percent
L19	TV Technician I	TV Main Sewers	148.2	57
		Joint Sealing	9.3	4
		Manhole Inspections	40.0	15
		Infiltration/Inflow In'vst	12.4	5
		Equipment Servicing	5.9	2
		Training	13.0	5
		Leave and Holidays	31.2	12
		Totals	260.0	100
L20	Maintenance Man II	Building Sewer Repairs	114.0	44
		Manhole Inspections	71.0	27
		Industrial Waste Insp'tns	17.2	7
		Buildings and Grounds	13.6	5
		Training	13.0	5
		Leave and Holidays	31.2	12
		Totals	260.0	100
L21	Maintenance Man I	Building Sewer Repairs	114.0	44
		Manhole Inspections	71.0	27
		Industrial Waste Insp'tns	17.2	7
		Buildings and Grounds	13.6	5
		Training	13.0	5
		Leave and Holidays	31.2	12
		Totals	260.0	100
L22	Maintenance Man I	Building Sewer Repairs	114.0	44
		TV Main Sewers	74.1	28
		Infiltration/Inflow In'vst	12.4	5
		Buildings and Grounds	15.3	6
		Training	13.0	5
		Leave and Holidays	31.2	12
		Totals	260.0	100
L23	Maintenance Mechanic II	Lift Station Insp and Serv	69.3	27
		Lift Station Repairs	40.0	15
		Equipment Servicing	106.5	41
		Training	13.0	5
		Leave and Holidays	31.2	12
		Totals	260.0	100
L24	Maintenance Mechanic I	Lift Station Insp and Serv	69.3	27
		Lift Station Repairs	40.0	15
		Equipment Servicing	106.5	41
		Training	13.0	5
		Leave and Holidays	31.2	12
		Totals	260.0	100
L25	Electrician	Lift Station Insp and Serv	69.3	27
		Lift Station Repairs	40.0	15
		Equipment Servicing	106.5	41
		Training	13.0	5
		Leave and Holidays	31.2	12
		Totals	260.0	100
		Grand Totals	6500.0	2500

task. Depending on their work load, as an emergency crew, they can often be used for a variety of other activities. Some of these other activities are described in the following paragraphs.

- Inspection. They can be an effective inspection team to seek out and report any unusual conditions that develop within the collection system.
- Repair crew. They can be used as a repair crew. However, such activities should be limited to minor repairs only.
- Map checking. Any existing mapping system should be monitored in the field to assure that recent additions and/or changes have been reported and included on updated maps.
- Inflow and infiltration investigations. During rainy weather these crews can be useful in locating points of inflow through unauthorized points of entry into the collection system. By monitoring specific portions of the collection system where surcharging is present, they can provide valuable information about inflow/infiltration areas.
- Scheduled maintenance. If your maintenance program includes rodding, either hand-rodding or power-rodding, the emergency crew could also serve as the rodding crew.

These are just a few of the various fill-in types of activities which can be performed by emergency crews. Even in large collection systems there are slack periods when emergencies are few and such crews can be efficiently used by assignment of fill-in work.

There is, however, one important point to consider in relation to such crews. Their primary responsibility is responding to emergency calls. Any fill-in work should, of necessity, be secondary in nature and of a type that can be quickly dropped to allow the crew to respond to the emergency at once when one develops.

BALLING CREW. Many preventive maintenance programs have one or more balling crews, depending on local conditions. The number required and the extent to which they can be used relates directly to the size of the collection system and the conditions within that system. Many larger agencies use several full-time balling crews. Smaller organizations might require only one crew on a part-time or full- time basis.

Balling crews commonly consist of three operators. There could be circumstances where additional operators may be required. If the work is being carried on in a main traffic artery, additional operators may be required for traffic control. In large sewers, where a substantial amount of material is being removed, more operators may be required to aid in the removal of such material. However, it is usually not necessary to have the larger crew for such specific circumstances on a regular basis. When such conditions are encountered, additional operators can be provided by combining available crews.

When not used on a full-time basis, balling crews can be assigned other duties.

- Repair crew. Three operators are adequate for many routine repair jobs.
- Smoke testing. Depending on the terrain and the scope of the smoke testing program, three operators can be sufficient for limited programs.
- Chemical crew. Again, depending on the scope of the program, three operators would be adequate in most situations.
- Bucketing crews. On a part-time basis, three-operator balling crews also can operate bucket machines.

FLUSHING CREWS. In recent years the practice of flushing has rapidly diminished. Experience has taught most supervisors that this practice is of little value in cleaning a collection system in most situations. The most to be accomplished by flushing is a temporary increase in flow velocities. Such increased velocities merely spread out accumulated deposits over a larger area within the system. The only effective method of cleaning a sewer is to remove deposits. Flushing will not remove deposits.

If you feel you must flush a sewer, two methods have been commonly used. Use the nearest available fire hydrant and a fire hose to flush the sewer. Local regulatory agencies often require an air-gap or back-flow protection between the domestic water supply and the wastewater collection system when this method is used. Another simple method is to use a water truck to transport water to the manhole. In either case, a two-operator crew would be sufficient.

HIGH VELOCITY CLEANERS. This equipment is an important part of any preventive maintenance program. Two operators are adequate to operate high velocity cleaners. However, in some areas, three operators are used if the cleaner does not have a vacuum device for removing debris and someone must enter a manhole to remove debris. Most organizations who possess this equipment will operate it on a full-time basis. Rarely is this equipment parked and the crew used for other activities.

POWER RODDERS. Many agencies operate this equipment full-time, on a year-round basis, and consider it an important part of their preventive maintenance program. However, the value of this practice is considered debatable by many experienced maintenance supervisors.

The equipment is available in either truck-mounted or trailer-mounted models. In either case, two operators are sufficient to operate such equipment.

In organizations where the equipment is not operated full-time, it is common to find a trailer-mounted unit kept available for use whenever necessary for specific conditions. Whenever this practice is followed, it is unnecessary to permanently staff operators for power rodders because they can be operated when needed by other available crews as suggested within this section.

BUCKET MACHINES. In large collection agencies bucket machines are used on a full-time basis with permanent crews assigned to such activities. Other agencies will have bucket machines on a stand-by basis, to be operated only part-time to deal with specific problems. In either situation, a three-operator crew will usually be adequate, As with a balling crew, additional operators may be necessary for traffic control or to help remove a large amount of material from the sewers.

CHEMICAL CREWS. Chemical crews rarely require a full-time staff. Many agencies consider chemical application a routine part of the activities of existing maintenance crews.

A variety of chemicals are used for collection system maintenance. The methods of application are as varied as the types of chemicals being used. Some require simple application of chemicals into manholes or other collection system openings. Other chemicals require plugging of downstream manholes and retention of chemical solutions within the section of line being treated for a prescribed period of time. Obviously, the number of operators required will vary with the method of application being used. Depending on the type of chemical and the method of application involved, any available two- or three-operator crew should be adequate to temporarily handle this assignment.

REPAIR CREW. If the crew is to be operated on a full-time basis, three operators should be provided. A crew of this size will be adequate for most routine repair activities. If repairs of a larger scope must be undertaken, two or more crews can be combined. As previously suggested, other available existing crews could be assigned repair work on a part-time basis.

CONSTRUCTION CREW. Many maintenance supervisors draw a fine distinction between what constitutes a construction crew and what makes a repair crew. A logical distinction would seem to be that construction crews are engaged in new work, while repair crews deal primarily with replacement of defective portions of the collection system. Other maintenance organizations will make no such distinction. However, larger agencies often undertake construction of significant scope such as replacement of 100 feet, 200 feet, or more of damaged or defective main line. In many larger cities, also, all new building service lines for both residential or commercial properties will be constructed by collection system operators when they are to be installed in public right of ways. Such construction will require backhoes, dump trucks, and other construction equipment, and the necessary operators to operate such equipment. These crews should be three-operator crews; but they will often be combined to provide for one-day completion of work in heavily traveled streets to minimize overnight disruption of normal traffic flow.

REHABILITATION CREW. Very large organizations may have a sufficient amount of sewer joint and manhole sealing and sewer lining to find it cost effective to have a full-time rehabilitation crew consisting of three or four operators with all the equipment necessary for this type of work activity. On the other hand, small organizations will generally find that contracting for the personnel, equipment and materials for sewer rehabilitation will be the most cost effective solution to leaky joint problems. Medium-sized organizations may use their own operators part-time and lease the equipment needed for sewer rehabilitation work activities. Suppliers of rehabilitation equipment and materials should provide assistance for the training of both full-time and part-time rehabilitation crews.

MECHANICAL MAINTENANCE CREW. A mechanical maintenance crew, usually consisting of two mechanics and an electrician, is used by an organization that has several medium and large size wastewater lift stations in their collection system. The second mechanic serves as a helper in work activities and as a third person for safety purposes.

If the crew isn't needed full time to inspect, service and repair lift stations, their mechanical and electrical abilities can be used for the servicing and maintenance of the equipment used by the organization for operation and maintenance of the collection system.

INSPECTION CREWS. Inspection crews should not be confused with construction inspectors or building inspectors. Historically many organizations have employed one or more collection system operators on a full-time basis simply to inspect their system. This inspection procedure usually consisted of opening manholes and noting the conditions therein on report forms. The efficiency and effectiveness of such procedures is very questionable and you should consider whether the benefits to be realized from such a program justify the costs. This procedure may be effective in specific problem areas where the inspector is looking for the causes of a problem.

Today, many organizations assign inspection crews only when they need to locate and identify specific problems in certain areas. To meet this need on a part-time basis, it is common practice to use other available two-operator crews whenever necessary.

Properly trained inspection crews can be very valuable. They can determine the validity and nature of complaints, identify problems caused by industrial dischargers, and pinpoint the locations of trouble spots. Operators on this type of crew should be thoroughly familiar with the collection system layout, the location of problem dischargers and something about their discharge schedules or practices.

CLOSED-CIRCUIT TELEVISION (CCTV). A three-operator crew is adequate. CCTV equipment, when available, is usually operated on a full-time basis. In most cases agencies that are large enough to purchase this rather expensive equipment will have sufficient work load to keep the CCTV equipment operating on a full-time basis.

When CCTV equipment first became available for use in the field of wastewater collection system maintenance, it was believed by many to be too complex to be operated by collection system operators. Experience has shown otherwise. CCTV equipment available today can be operated effectively by existing collection system operators with proper training. While CCTV is not particularly complex or difficult to operate, crews should have time to become thoroughly familiar with it in order to operate it with a minimum of down time. Good practice is to rotate crews, whenever possible, to assure trained operators are available whenever necessary. With some CCTV equipment, once the TV camera is in the sewer, only one operator is needed to televise the sewer and record observations.

SMOKE TESTING CREW. Rarely is there sufficient work to require a full-time crew. Smoke testing is usually undertaken to locate and identify points of inflow and illegal connections. After an area has been smoke tested, there is usually no cause to retest at least for a period of years.

As previously suggested, this function can be effectively performed by other existing crews within an agency. Smoke testing is an excellent operation to be assigned during wet or cold weather. This is the time of year when the conditions you are smoke testing to find are most prevalent. It is also the time of year, due to wet weather, that crews cannot perform their normal work and are available.

A smoke testing program of significant scope may require from three to five persons. The size of crew depends largely on the terrain of the area being tested. When using three or five-minute smoke bombs, it is often necessary to have three to five people to thoroughly inspect the area covered by smoke bombs. Combining available crews is an excellent source of obtaining the required operators.

AIR TESTING CREW. Since closed-circuit television equipment is frequently used in conjunction with pipeline integrity air testing equipment, it is logical to use the TV crew for air testing activities.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 454.

13.2A List the major work tasks performed by a collection system agency.

13.2B Why do maintenance crews tend to become more specialized in larger collection systems than in smaller collection systems?

13.2C What is the basic crew in most maintenance organizations?

13.2D How many operators are usually on an emergency crew?

13.2E List some of the other activities that might be done by an emergency crew when there are no emergencies.

13.2F What factors help determine the number of operators on a balling crew and the extent to which they are used?

13.2G What other jobs are often done by balling crews?

13.2H How often are high velocity cleaners commonly used?

13.2I Is closed-circuit television equipment too complex to be operated by most collection system operators?

13.2J Why should crews be rotated from job to job?

13.2K What is the function of a smoke testing crew?

13.2L What is the difference between a repair crew and a construction crew?

END OF
LESSON 1 OF 4 LESSONS
ON
ORGANIZATION FOR SYSTEM
OPERATION AND MAINTENANCE

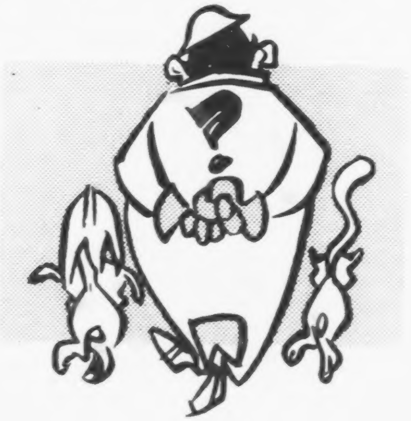
DISCUSSION AND REVIEW QUESTIONS

Chapter 13. ORGANIZATION FOR SYSTEM OPERATION AND MAINTENANCE

(Lesson 1 of 4 Lessons)

At the end of each lesson in this chapter you will find some discussion and review questions that you should answer before continuing. The purpose of these questions is to indicate to you how well you understand the material in this lesson. Write the answers to these questions in your notebook before continuing.

1. Why does a collection system agency need to be organized?
2. How is a knowledge of the work required of an organization determined?
3. In addition to an operator's existing skills, what factors should be considered when assigning operators to a crew?
4. How would you determine the types of crews needed to operate, maintain and repair a wastewater collection system?
5. How would you determine the number and sizes of crews for a wastewater collection system?



Chapter 13. ORGANIZATION FOR SYSTEM OPERATION AND MAINTENANCE

(Lesson 2 of 4 Lessons)

13.3 CLEARWATER COLLECTION SYSTEM DIVISION ORGANIZATION

Continuing with the Clearwater, USA example, let us now consider how the new superintendent reorganized the division that operates and maintains the city's wastewater collection system.

13.31 Service Request and Preventive Maintenance Section

The first priority of a wastewater collection system agency should be to have the ability to handle emergency service requests quickly and efficiently. Emergency service requests usually consist of calls to remove main and building service line stoppages and causes of flooding and to correct lift station failures.

Sewer line stoppages can develop when an obstruction causes debris to build up and slow down the flow of wastewater, gradually forming a block or halt of the flowing wastewater. Clearing stoppages quickly before major flooding and damage occur is a major concern.

For the sake of recording stoppages for follow-up maintenance work, stoppages must be identified according to the cause or type of problem. Stoppages are caused by obstructions such as roots, grease, debris, broken pipe or a joint failure. These obstructions may require removal, repair, or replacement immediately to correct the problem. See Chapter 6, Volume I, Section 6.121, Type of Stoppages, page 264, for a discussion of the causes of various types of stoppages.

A main line stoppage is a major problem and can affect many customer services on that portion of a collection system. A main line stoppage is usually discovered by a private citizen who telephones into the office to report that a manhole is overflowing.

A building service line stoppage usually affects only the home or business that is served and the home resident telephones in when their sinks or toilet facilities will not drain.

The Clearwater Service Request (emergency service) and Preventive Maintenance section is organized, as illustrated in Table 13.3, for responding to remove main line and building service stoppages. The Power Rodding Crew or the High Velocity Cleaner Crew remove main line stoppages and the Hand Rodding Crew removes building service stoppages.

13.311 Responding to Requests for Stoppage Removals

In either of the above cases, the office personnel receiving the call should record the following information in a permanent log:

- Date,
- Time call was received,
- Name of person calling,
- Phone number of person calling,
- Street address where problem is occurring (mailing address also is important, if different from street address, for billing purposes if agency serves more than one sewer assessment district), and
- Type of problem they are reporting.

The dispatcher will have the following priority list:

1. Flooded home or business (main line or service line stoppage),
2. Manhole overflowing (main line stoppage),
3. Manhole cover off (liability risk),
4. Cleanout overflowing (nuisance and health hazard), and
5. Home service backed up.

When a problem is reported, the dispatcher radios the supervisor of the Service Request and Preventive Maintenance Section to provide the address or location, and describe the nature of the problem. Also, the dispatcher will be responsible for:

- Recording the time the call was dispatched to the supervisor, and
- Recording the time the service crew or their supervisor reports the correction of the problem.

When multiple emergency calls are received at the same time, the dispatcher contacts the supervisor first. The service crew will first respond to the highest priority call and the supervisor to the other calls. The supervisor evaluates the problems, assigns priorities, redirects service crews, and requests assistance from preventive maintenance crews for specific equipment or assistance in handling calls as necessary.

The office staff are responsible for records, reports and accuracy of the initial phase of service requisitions.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 455.

13.3A List the priority responses to requests for emergency service.

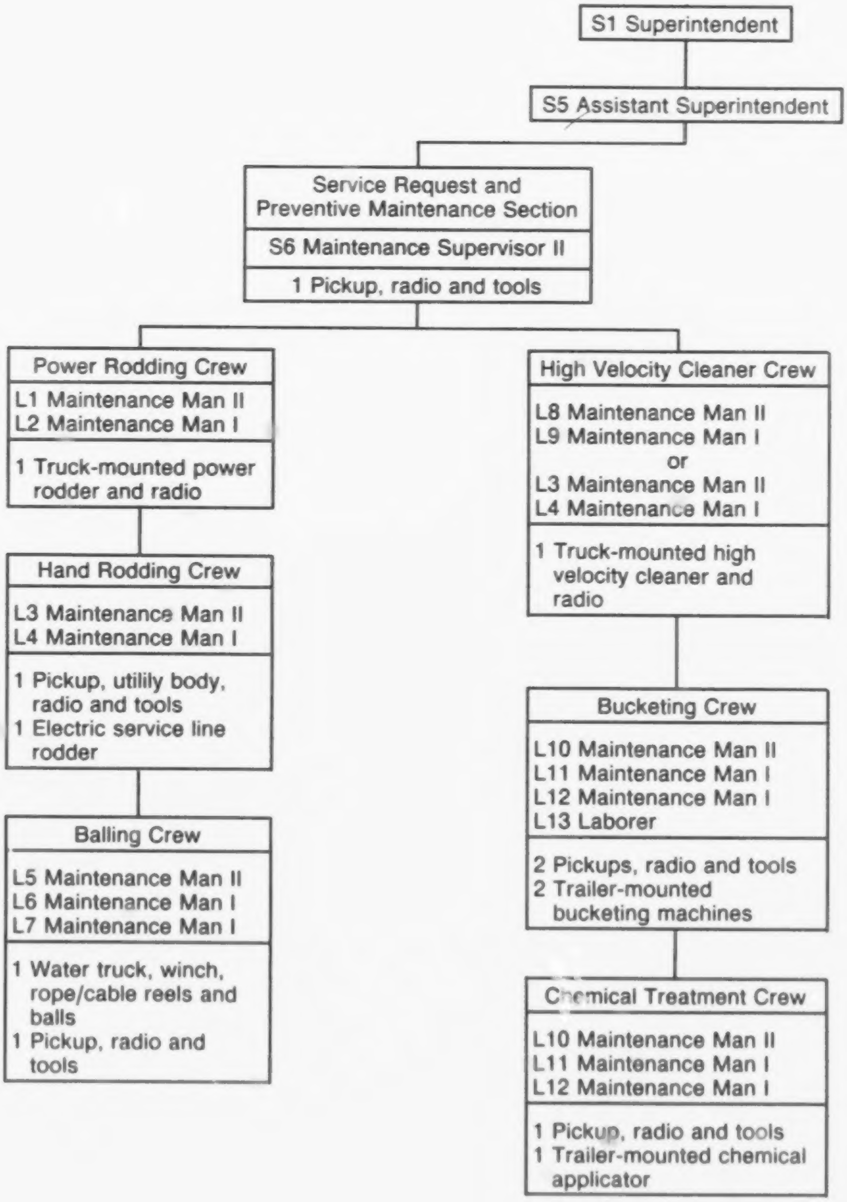
13.3B What does the field supervisor do when multiple emergency calls are received?

13.312 Flooding Caused by Stoppages

One of the most delicate problems of public relations which Clearwater or any other agency must face is the occasional flooding of a home, a business, or a street area caused by a main line stoppage and the resulting backup of wastewater. Despite the risk of incurring increased liability, either your insurance carrier, a janitorial or sanitation cleanup service, or an agency crew should be sent to the property to assist in cleaning and removing articles which may have been damaged or will be damaged if left in place. These crews should be the first line of defense and be alerted when the possibility of flooding occurs. Response calls must be prompt. Dispatchers handling such calls may be able to give instructions to the homeowner which will avoid damage from impending wastewater flows.

Above all, you and your fellow operators must follow policies which have been approved by your agency's legal department because flooding often leads to law suits. When possible, a radio-dispatched crew should be sent to investigate any irregularity in the functioning of a building's plumbing system. This is a good opportunity to locate the trouble and determine whether or not it is the city's or agency's responsibility which has caused the backup flow damage. Disputes often arise regarding whether stoppages occurred in a main line or a house service line on or off private property. Problems can be avoided by thoroughly investigating the cause and location of the problem whenever a stoppage is cleared.

TABLE 13.3 SERVICE REQUEST AND PREVENTIVE MAINTENANCE SECTION ORGANIZATION


S1 Superintendent
S5 Assistant Superintendent
Service Request and Preventive Maintenance Section
S6 Maintenance Supervisor II
1 Pickup, radio and tools
Power Rodding Crew
L1 Maintenance Man II
L2 Maintenance Man I
1 Truck-mounted power rodder and radio
Hand Rodding Crew
L3 Maintenance Man II
L4 Maintenance Man I
1 Pickup, utilily body, radio and tools
1 Electric service line rodder
Balling Crew
L5 Maintenance Man II
L6 Maintenance Man I
L7 Maintenance Man I
1 Water truck, winch, rope/cable reels and balls
1 Pickup, radio and tools
High Velocity Cleaner Crew
L8 Maintenance Man II
L9 Maintenance Man I
or
L3 Maintenance Man II
L4 Maintenance Man I
1 Truck-mounted high velocity cleaner and radio
Bucketing Crew
L10 Maintenance Man II
L11 Maintenance Man I
L12 Maintenance Man I
L13 Laborer
2 Pickups, radio and tools
2 Trailer-mounted bucketing machines
Chemical Treatment Crew
L10 Maintenance Man II
L11 Maintenance Man I
L12 Maintenance Man I
1 Pickup, radio and tools
1 Trailer-mounted chemical applicator

Note: One pickup assigned to the bucketing crew will also be used by the chemical treatment crew.

If flooding has occurred due to a stoppage in a main sewer line and the city or agency is responsible, the crew should follow set procedures for unplugging the stoppage and for helping to clean up the building or home. Always advise your legal department immediately of what has happened and exactly what actions you took. In many cases, the legal department or insurance company will be able to make an out-of-court settlement for damages incurred, thus saving the city or agency the high court costs.

An agency should have cleanup equipment available or prior arrangements with a sanitation service company to respond quickly to any location in need of wastewater cleanup service. This procedure insures a rapid cleanup of wastewater from the household area and will result in less water damage. For example, the quick removal of water will save existing hardwood floors from warping or floor tiles from becoming loose. Many other articles can be salvaged, and prompt action can bring down the cost or expense of replacing articles only slightly damaged.

If the flooding was caused by the failure of a pump that was supposed to discharge the wastewater from the basement of a home or business, the community policy must clearly define who is responsible for the operation and maintenance of the pump. If the flooding is caused by a low service line in relation to the collection system and is an overflow point, then a backflow preventer and an overflow valve should be installed to prevent future flooding. Agency policy must clearly state who is responsible for maintaining these items. Many health departments dislike overflow valves, but if homeowners are given the choice of either flooding their family room carpet with wastewater or flooding the front lawn, they would prefer the lawn.

Every collection system agency has the responsibility of developing policies and guidelines which clearly state the limits of agency responsibility. Also the responsibilities of homeowners must be communicated to homeowners affected by agency policies.

13.313 Other Requests

Collection system agencies frequently receive calls about water leaks from domestic water supply systems; these should be referred to the water department. Requests to help recover valuable items such as diamond rings, jewelry, money, false teeth, and keys that have been lost down the drain or flushed down the toilet must be handled according to agency policy. If attempts are made to recover these items, the work should be assigned to a balling crew to clean the portion of the main line downstream of the building service. Very often, recovery of these items greatly enhance the public's image of the agency.

Responding to these requests is time-consuming and expensive, but may be worth the expense if crews are available. Establish a policy for handling these requests if the frequency exceeds one per month. Be sure to include in the policy a disclaimer of responsibility for recovery of lost items; the only chance of finding them would be in some trap or constriction that serves as a trap for heavy objects.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 455.

13.3C What should be done when a private home becomes flooded with wastewater?

13.3D How can legal problems resulting from flooding be minimized?

13.3E How can flooding problems caused by a low service line in relation to the collection system be corrected?

13.3F Who should handle service requests to have valuable property recovered from a sewer?

13.314 Service Crew Functions

The crews responding to requests for service should function in the manner described in the following paragraphs.

EN ROUTE TO PROBLEM AREA. Upon receipt of assignment from dispatcher or field supervisor, the crew performs the tasks listed below en route to the problem.

- Begin to fill out service request form. Record:
  a. Time call received,
  b. Street address of problem, and
  c. Unit number and names of crew members.
- Obtain map of problem area from vehicle map storage file.
- Notify dispatcher upon arrival at problem area of time of arrival and location of unit. If supervisor or crew cannot locate problem, ask dispatcher to verify service request or complaint with party who submitted original call.

MAIN LINE STOPPAGE. On a main line stoppage (manhole overflowing), the crew leader examines the maps to determine direction of flow. The downstream manhole is inspected and observed for no flow or if the flow is restricted or reduced through the manhole or backed up into the manhole. When the manhole with reduced flow or no flow is located, the stoppage is located between this manhole and the upstream manhole. A service crew is directed to the lower manhole and starts to work upstream to clear the blockage.

A service crew usually will be equipped with a power rodder. The supervisor may direct a high velocity cleaner crew to remove a main line stoppage if the power rodder is not available or the use of the cleaner is more appropriate for removal of the stoppage. In either situation, main line stoppages will be removed in accordance with the procedures described in Chapter 6.

SERVICE LINE STOPPAGE. When a service line stoppage occurs, the first job the hand rodding crew does upon arrival is to inspect the main line. Inspection of the upstream and downstream manholes on the main line will verify if the main line is open and flowing. If the main line is not flowing or if it is surcharged, the crew inspects the main line until the area of the stoppage is located. The crew then requests the assistance of the power rodding crew to remove the stoppage.

If the main line is clear and flowing, the crew proceeds to the service address. The service line cleanout is inspected to determine if the portion of the service line from the property line to the main line is clear of obstructions. To do this, remove the cleanout cover and run a hand rod with a 2 or 3½-inch auger down the cleanout to the main line. Make sure that sufficient rod is used to reach the main line according to the distance shown on the map and your estimate of the distance. Sometimes service lines can be cleared using a plunger-type tool. By placing the plunger at the bottom of the cleanout and yanking upwards, the suction pressure created may clear the stoppage.

If a cleanout is not available, the crew or supervisor (after inspecting the main line) may inform the resident that it is not the agency's problem and that they should call a plumber (the crew or supervisor's response should be dictated by agency policy). If a plumber inspects the building service line and finds the line is open from the house to the property line and the service line is still plugged, then a service crew returns to the problem area. The crew digs up the service line, the line is cut into, rodded, and the blockage cleared in the street or easement area to the main line, and service is restored. Cover boards three-quarter inch thick and 4 feet by 4 feet are placed over the excavation to prevent people or animals from falling into the excavation. A barricade is placed on the cover board over the excavation to warn people of the excavation until a cleanout is installed and the excavation is filled.

COMPLETION OF FORMS. When the work is finished, the service report form is completed (Figure 12.23). Essential information includes:

- Cause of problem—roots, rags, grease,
- Time job completed, and
- Staff-hours required.

The crew also fills out a repair request giving the following information:

- Nature of repair (install cleanout at property line),
- Address of repair,
- Map location,
- Size of service line and material of line,
- Depth of service line,
- Date requested, and
- On the back side of the card, draw a map showing the property serviced, distance to street or easement, major buildings or identifying marks to identify location of new cleanout (Figure 7.35, page 400, Volume I).

Persons occupying the service building are informed that service is restored and the dispatcher is notified that the crew is returning to its scheduled assignment and/or available for another assignment.

A repair and replacement crew will install the new cleanout, fill in the excavation, and restore landscaping to previous condition. The next time a service request is made to this address, the cleanout will permit a service crew to rod from the new cleanout to the main line. The problem can be removed or the resident can be informed that it is their problem and that they must hire a plumber to clear the service line from the building to the property line.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 455.

13.3G What does an emergency service crew do en route to a problem area?

13.3H How is the location of a main line stoppage determined?

13.3I How are stoppages removed?

13.3J What is the first job the crew does upon arrival to clear a service line stoppage?

13.3K How is a service line stoppage cleared?

13.3L What forms should be completed after clearing a service line that required the line to be dug up?

13.3M Which crew should install a new cleanout if one is required?

13.315 Preventive Maintenance

A review of the past records of Clearwater's preventive maintenance unit reveals some very serious problems. The crews were on the job and working, but there had not been a significant reduction in the number of main line stoppages and service requests during the past few years. The reason for the lack of a reduction appears to stem from two sources. The condition of the system is not known and the field crews need special training on when, where and how to use the available equipment and the effectiveness of the equipment.

The new superintendent of the Clearwater Collection System Division plans to use about eighty percent of the work time of the Service Request and Preventive Maintenance Section on cleaning and chemically treating Clearwater's lateral, main, trunk and interceptor sewers. This emphasis on preventive maintenance is expected to reduce the number of requests for the removal of stoppages, restore full flow capacity and extend the service life of the system.

13.316 Preventive Maintenance Crew Functions

A wastewater collection system cleaning schedule is developed by the section supervisor and the superintendent. The procedure for preparation of the work schedule is described in Section 13.6.

A priority list helps to provide an organized approach to solving problems when they develop and insuring the completion of necessary work. The Clearwater Superintendent developed the priority list shown below.

- Assist emergency service crew to clear difficult stoppages on request.
- After emergency service crew reports the clearing of a main line stoppage, clean segment of line where stoppage occurred within three days.

- In lines with known root problems, schedule power rodder to clear problem areas. If emergency service crews receive requests for same location more than once in a six-month period, schedule power rodder in problem area more frequently and try to control roots using chemicals (Chapter 6, Section 6.5, Chemicals, page 338, Volume I).
- In lines with known grease problems, schedule high velocity cleaner to clean lines more often when service requests indicate a more frequent schedule is necessary.
- Assign cleaning units to areas of collection system to be cleaned this year.
- Construct training facility (Figures 13.1 and 13.2) and provide training sessions for all preventive maintenance cleaning crews.
- Develop priority list of portions of collection system to be inspected by rented closed-circuit television inspection unit.
- Prepare and schedule program to chemically treat fifteen miles of sewers with serious root problems (see Chapter 6, Section 6.53, Roots, page 340, Volume I). Program should include the following items:

a. Research literature for available chemicals, methods and success of attempts by others to chemically treat lines to control roots.

b. Visit agencies with similar problems who are using chemicals to control roots; evaluate effectiveness of their efforts and discuss with them their ideas for better results.

c. Select at least two methods of chemical treatment and test on a section in selected area to evaluate effectiveness of methods.

d. Keep records of all aspects of chemical treatment program including labor, equipment, chemicals and regrowth of roots to evaluate cost effectiveness of program.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 455.

13.3N Why should a priority list be developed for scheduling work by preventive maintenance crews?

13.3O What is the priority list developed by Clearwater for the preventive maintenance crews?

13.3P What items should be considered during the preparation and scheduling of a chemical treatment program for root control?

13.317 Equipment

A broad range of equipment for the operation and maintenance of wastewater collection systems has been described in previous chapters of this manual and should be reviewed for information on specific types of equipment and their operation. The following is a description of equipment generally used by service response and preventive maintenance crews. Since the City of Clearwater's wastewater collection system is medium sized, its service response and preventive maintenance crews will not have all the equipment described.

SERVICE RESPONSE EQUIPMENT. Crews responding to service requests should have access to a power rodder, high velocity cleaner, and an electric building service rodder. They will need a vehicle, preferably a 3/4 or 1-ton truck with a utility body, stocked with the following equipment:

- Radio with field call. The field call provides a means for the dispatcher to summon the crew to the unit's radio when they are working away from the truck. The device blows the vehicle's horn and turns on the rotating beacon if it is not in use. Some agencies place a speaker on the outside of a vehicle. If this type of equipment is not available or is too expensive, use a "pager." This equipment enables the dispatcher to start a buzzer which signals the operator in the field to phone the dispatcher.
- A complete set of maps of the collection system. If a complete set becomes too bulky, record the maps on microfilm and use a viewer.
- Field report forms as required.
- Sewer rods, reel, and various sizes of augers.
- A small, portable, power rodding unit is very helpful for use as an aid in turning the sewer rods in difficult line stoppages.
- Detection equipment for toxic gases, explosive conditions and oxygen deficient atmospheres.
- Small air blowers for ventilation.
- Portable generator for lights and tools.
- Ladder for descending into manholes (considered safer than manhole steps; enter manhole only if three crew members are present).
- Safety harness and ropes.
- Poles with hooks for dislodging and removing obstructions found in a manhole.
- First aid kit.
- Waterless hand soap and rags.
- Buckets and rope hooks.
- Other basic equipment includes small tools, rubber boots, gloves, hard hats, shovels, locators, probes, cover boards, barricades, and traffic safety cones and warning signs.

All equipment should be on the vehicle for use when needed.

EQUIPMENT FOR PREVENTIVE MAINTENANCE. Crews performing preventive maintenance of wastewater collection systems should have the following equipment and operate it in accordance with the following procedures:

POWER RODDING MACHINE. May be truck-mounted or trailer-mounted. This equipment is quite versatile in some types of cleaning and maintenance. A power rodder is very effective in clearing a stoppage. The large assortment of tools that are available for use with the rodder allows it to be used for clearing various types of stoppages, cutting roots, removing grease and even clearing sand and grit—although not too effectively. Effectiveness in larger lines is reduced because of the tendency for the rods to coil and bend. Common procedure is to operate from the downstream manhole, especially when there is a stoppage in the line.

SEWER BALL, CONE AND KITE. The sewer ball is constructed of high grade rubber and is designed with spiral ribbing in order to create a spiral action of water in the line. Sewers are cleaned and scoured by the water flowing around the ball at a high velocity.

The balls come in assorted sizes and are inflated with air. At each end of a ball there is a lug or ear molded into the ball for attachment of a tag line or cable. The ball is inserted at the upper manhole. Air pressure in the ball should be enough to allow heavy flows of water to escape through the ribs on the ball. The tag line, or cable, is threaded through a manhole jack to the surface at a winch where it is controlled by an operator.

Water is introduced into the manhole and allowed to build up until two feet of head has been developed to create cleansing velocities around the ball. The speed of the ball moving down the line is controlled by the operator manning the upstream tag line. Crews must be trained to select the proper speed so the water passing around the ball will "wash" the material in the sewer down the line ahead of the ball. The cone and kite operate in a similar manner.

These pieces of equipment are effective in moving grit, sand and debris down the line to a manhole where it can be removed. Slime and grease can be removed from the sides of the pipes by these techniques. One of the undesirable features of using this equipment is the possibility of flooding basements which are located below grade level, or even the first floors of buildings if they are below the rim of the manhole used for balling. If the water head behind the cleaning equipment is not properly controlled, flooding may result and could cause considerable damage.

BUCKET MACHINES. The bucket machine consists of two power winches with cables running between them. When cleaning a section of line, the winches are centered over two adjacent manholes. To get the cable from one winch to the other, it is necessary to thread the cable through the sewer line by using a power rodder, parachute, float, or a high velocity cleaner. The cable from the drum of each winch is fastened to the barrel on each end of an expansion bucket so that the bucket can be pulled in either direction by the winch machine on the appropriate end. The bucket is fitted with a closing device and operates somewhat like a clam.

When a stoppage has been opened and the backed up water has been released, usually the large volume of debris that created the stoppage must be removed. If a bucket machine is used to remove the debris, the cable must be threaded through the stoppage area using a power rodder, high velocity cleaner, or by floating. Once a cable is threaded through the restricted section from an upstream manhole to a downstream manhole, the bucket machine winches may be set up and the line cleaned.

A bucket is pulled into the stoppage in the line until the operator feels that it is loaded with debris. The winch motor is then thrown out of gear and the opposite winch is put into action. When the reverse pull is started, the loaded bucket automatically closes and the debris is brought out through the manhole to the surface. The bucket is opened and the debris is deposited in a truck or on the ground or street surface. This operation is repeated until the line is clean. Units with conveyor truck loading mechanisms are available for a much neater operation.

Various bucket sizes are available for cleaning lines from six inches up to thirty-six inches. Buckets commonly are used for larger diameter lines because of the expense incurred for this type of cleaning. Bucket machine cleaning is effective in removing heavy concentrations of sand and debris from larger diameter lines, but is undesirable from the standpoint of damage that can be done to the lines and because it is a time-consuming operation.

SEWER SCOOTER. The sewer scooter creates high velocities of water that clean the walls of sewers. Like the ball, cone and kite, the sewer scooter depends entirely on the head of water behind the scooter to provide the cleaning velocity. The scooter runs on a sled-like apparatus that has wheels on the runners and a hinged gate affair to control the upstream water pressure. Drawbacks include being too difficult to use in smaller manholes. An effective job is done in removing debris, grease and slime from the line.

HIGH VELOCITY CLEANING MACHINES. High velocity cleaning machines are truck-mounted and usually carry 500 to 700 feet of hose capable of withstanding high pressures. Special nozzles can be attached to the hose for routine cleaning and for breaking stoppages in a sewer. These nozzles have jets at various angles in the rear to serve the dual purpose of propelling the hose up the sewer and cutting or moving material in the sewer at the same time. High velocity cleaning machines are probably the most effective of the cleaning equipment for removing grease, grit, sand, gravel, and debris. Traps at a downstream manhole always should be used with this operation to trap all debris and keep it from traveling farther downstream. Some high velocity cleaners are equipped with a vacuum pump and a tube that can be lowered into a manhole to suck out debris.

A limitation of high velocity cleaners is their ineffectiveness in areas that have steep grades and in large-diameter sewers. Sometimes they do not have sufficient water pressure to propel the nozzle up a line in areas of steep grades. Another problem is the danger of flooding a residence if the equipment is not properly used. In any case, the operator should be an experienced operator well versed in what could take place if the high velocity cleaning machine is not properly used.

FLUSHING. Flushing may be used for cleaning small sewers for short distances. Although flushing does not scour or clean the sewers of grease or grit, it does give the opportunity to inspect each manhole and flushing inlets. The main purpose of this operation is to thoroughly clean the manhole in the system and move any floatable debris downstream to a larger line. Occasionally, flushing helps locate a potential stoppage in the collection system. Either a fire hydrant and hose (with an air gap) or a water truck is used for a water supply.

RECORDS. A simple and useful type of recordkeeping system must be implemented when setting up a preventive maintenance program and should be maintained thereafter. Accurate records are one of the most valuable tools available for a maintenance department. The record cards aid the department in a number of ways. A complete up-to-date record system provides:

1. Details of all work done on the system, including dates,
2. Assistance in scheduling future work,
3. Justification for annual budgets,
4. Documentation for annual budgets, and
5. Protection against liability of the agency.

A record card file system should be kept giving all pertinent data of the collection system and maintenance performed on it. Records should be kept up to date, thus providing an accurate record of all work performed and all recurring sources of trouble in a collection system (see Chapter 12, Section 12.75, Records, page 375).

SUMMARY. All of the items and equipment that have been mentioned in this section were designed for a specific task and no single piece of equipment can be used to remedy all of the situations that may occur in a collection system.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 456.

13.3Q What are the major disadvantages of using a bucket machine?

13.3R High velocity cleaners are most effective in what kinds of situations?

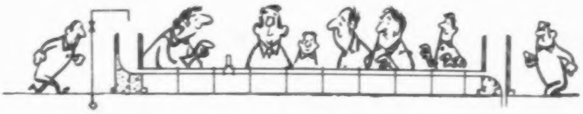
13.318 Training Crews

Training of field crews can be greatly improved by the construction of a 6-inch clear pipe (Figures 13.1 and 13.2) that allows the crews to observe what's happening in a line when the various types of cleaning equipment travel through it. This training line also should be used to train all field crews in the safe and proper use of sewer cleaning equipment. Pieces of equipment that can be used to train crews with this facility include:

- Hand rodders,
- Power rodders,
- High velocity cleaners,
- Sewer balls,
- Kites, parachutes, cones, and pigs,

- Sewer scooters, and
- Bucket machines.

In addition, the training facility can be used to teach crews how to flush lines, use chemicals and install plugs.



Observing the action of a piece of cleaning equipment on some grit or other test material in the clear pipe can be very helpful to a crew. The procedure is very simple. Deposit grit or test material in the upstream manhole (MH #1), turn on the water supply and flush the material into the section of clear pipe. Use the cleaning equipment the crew is working with to remove the grit. The crews can observe the effectiveness of the equipment, its limitations and how to use the equipment as efficiently as possible. Four hours of planned instruction using the training facility can be worth more than several months of on-the-job training in the field.

13.32 Repair and Replacement Section

All repairs to sewers and manholes and installation of new or replacement sewers and manholes (within the limitations of equipment, manpower and time) are done by this section. To help you determine whether or not a project should be undertaken by this section or by a private contractor, review the set of guidelines below. A private contractor should be considered if the following conditions exist:

- Cost of material for a single job is over $15,000. This value is a flexible guideline and depends on how busy repair crews are when the job needs to be done, local regulations, and the desires and willingness and ability of local contractors to do the job.
- Time to complete the job is more than ten days. Again this time period is a flexible guideline and depends on how busy repair crews are when needed and the desire and ability of local contractors. Repair crews should not become involved in large jobs requiring over ten days because they have other work that should be done. Also, competitive bidding among contractors

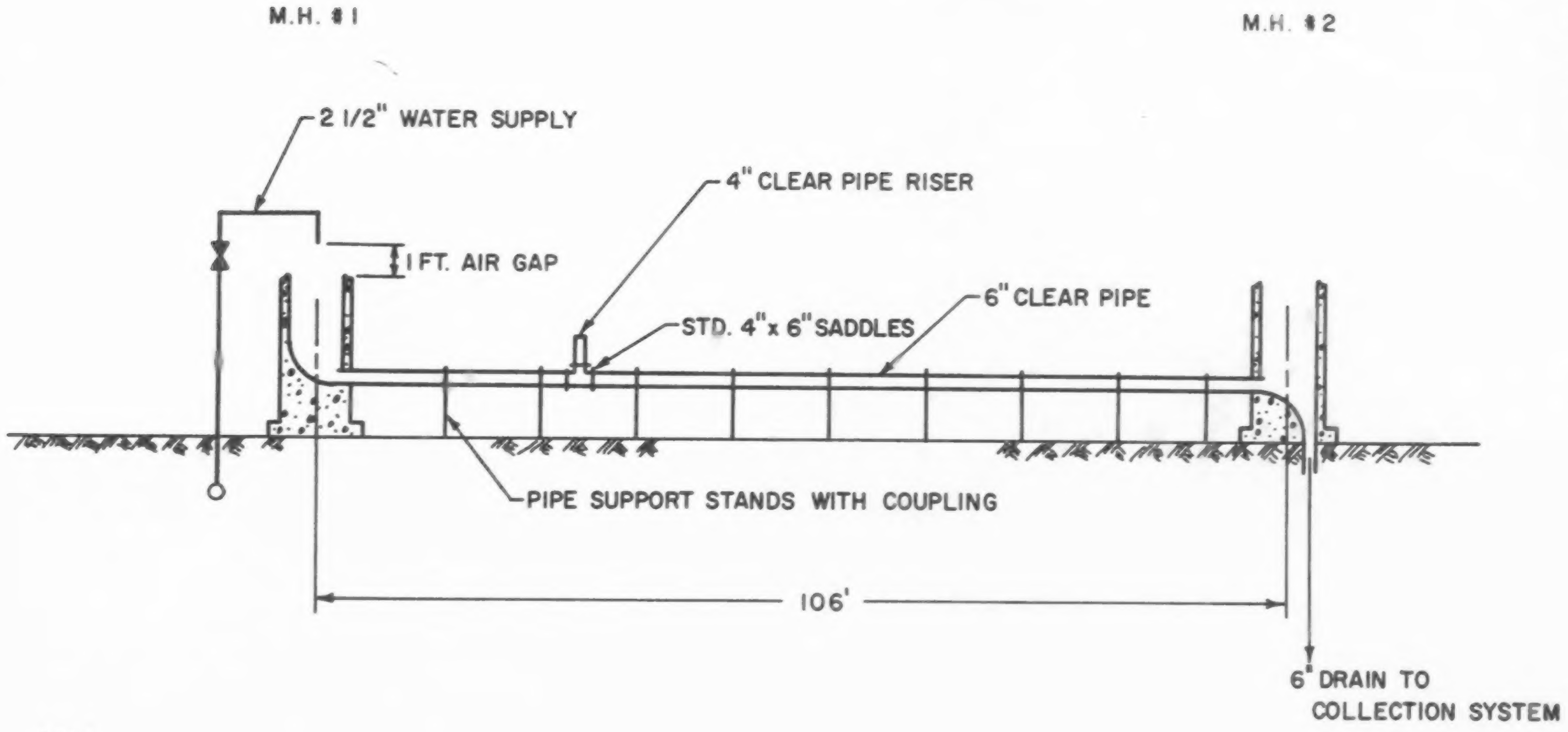
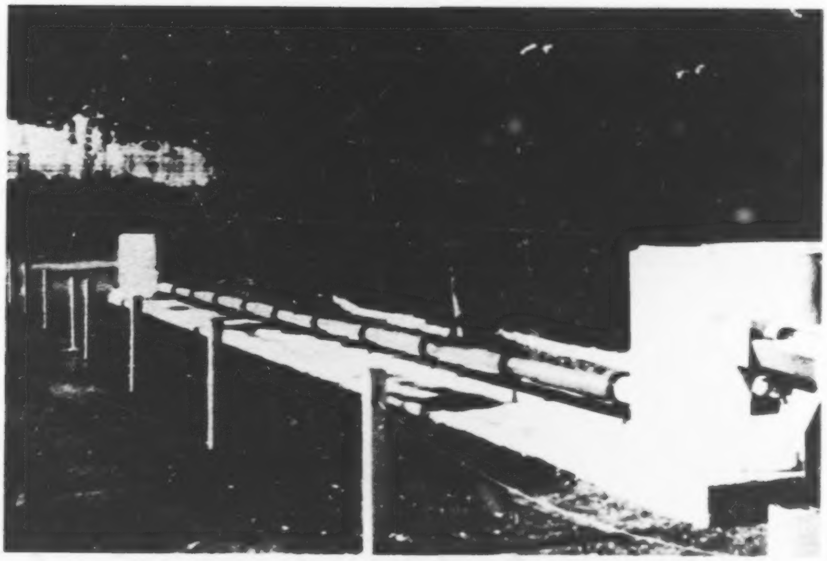

M.H. #1
M.H. #2
2 1/2" WATER SUPPLY
4" CLEAR PIPE RISER
1 FT. AIR GAP
6" CLEAR PIPE
STD. 4" x 6" SADDLES
PIPE SUPPORT STANDS WITH COUPLING
106'
6" DRAIN TO COLLECTION SYSTEM

Fig. 13.1 Training facility pipe layout.



Entire facility

Cleaning action of sewer ball

Fig. 13.2 Actual training facility
(Courtesy of Sacramento County)

may get the job done at a more reasonable price. Repair crews should do emergency work if necessary and obtain assistance from contractors without bids for critical emergency jobs.

- Special construction or safety equipment will be required. Examples of special equipment include deep shields for shoring or considerable pumping capacity to dewater excavations in areas with a high water table.

The organization of the Repair and Replacement Section is shown in Table 13.4. Crew 1 will make main sewer repairs and new sewer installations, Crew 2 will make manhole repairs and an infrequent manhole replacement or construction of an additional manhole, and Crew 3 will make building sewer repairs and replacements. Crew 3 will also install property line cleanouts.

Activities of the Repair and Replacement Section are generated by the need for repair and replacement of building service, lateral, main, trunk and interceptor sewers observed by the crews in the Service Response and Preventive and Inspection Sections. Crew leaders' requests for repairs or replacements are processed through the management information system, described in Section 12.7 of Chapter 12, page 363, and result in work directives issued by the superintendent or supervisor to the appropriate Repair and Replacement Section crew.

13.321 Repairs

The following procedures are to be followed by crews making repairs:

- Section Supervisor to review each work order and to assign priority to jobs. Priority assignment will be either *IMMEDIATE REPAIR* or *REPAIR WHEN TIME AVAILABLE.* Jobs will be assigned to the appropriate crew.
- Safety orders are to be followed by all operators.
- All operators are to be trained once a year in shoring of excavations.

SHORING SCHOOL

- Crews working in easements and back yards must show proper respect for private property. Every effort must be made to restore area to original conditions, including replanting lawns and replacing shrubbery. Trees interfering with collection system operation or repair are to be removed, after informing property owner, and should not be replaced in easement.
- Whenever possible all excavations should be filled at the end of each day. Work overtime if necessary. Any open excavations must be covered with adequate strength materials and properly marked with signs, barriers and flasher signals.
- All tap repairs and new taps will be made by repair section. Plumbers will not be allowed to make any taps into Clearwater's collection system.
- All main line stoppages that require digging will have wastewater pumped from upper manhole to lower manhole, thus isolating the portion of line under repair whenever practical. Raw wastewater may be bypassed into a storm drain or open water course only upon approval of superintendent and after notification of appropriate authorities (local officials and water pollution control agencies).

13.322 New Construction

Repair and Replacement Section crews performing new construction will use the following procedures:

- New system work will be completed on the basis of work orders. New service connections may require plumbing permits and other necessary permits to be obtained by the contractor.
- A flat fee will be charged for single family residence service connections. Commercial and industrial connections will be charged on basis of a field cost estimate by the New Construction Unit Supervisor. Supervisor to contact Industrial Waste Supervisor on all commercial and industrial connections to determine need to install special equipment. This equipment will meter and sample effluent to meet sewer-use ordinance requirements for billing and compliance with waste discharge requirements.
- Section supervisor should periodically review the section's organization. Consideration should be given to expanding crews during the summer months for repairs. Permanent crew size should be small because repair excavations should be minimized during adverse weather, except for emergencies. In areas where the weather is always poor, repair crews may have to work under adverse conditions almost all year.
- Section supervisor is to collect cost data and compare economics of purchasing heavy equipment (5-yard dump trucks and backhoes) with renting necessary equipment. Clearwater needs one backhoe for use throughout the entire year and three backhoes for repair work during the eight-month dry season.
- The closed-circuit television inspection activity is expected to reveal considerable work for the repair crew. Experience by other agencies indicates that for every eight hours of collection system TV inspection, 24 hours of repair work will be discovered consisting of the following:

  a. Bad taps (including protruding taps),
  b. Bad joints,
  c. Offset joints,
  d. Broken pipes, and
  e. Deteriorated pipe.

13.323 Equipment

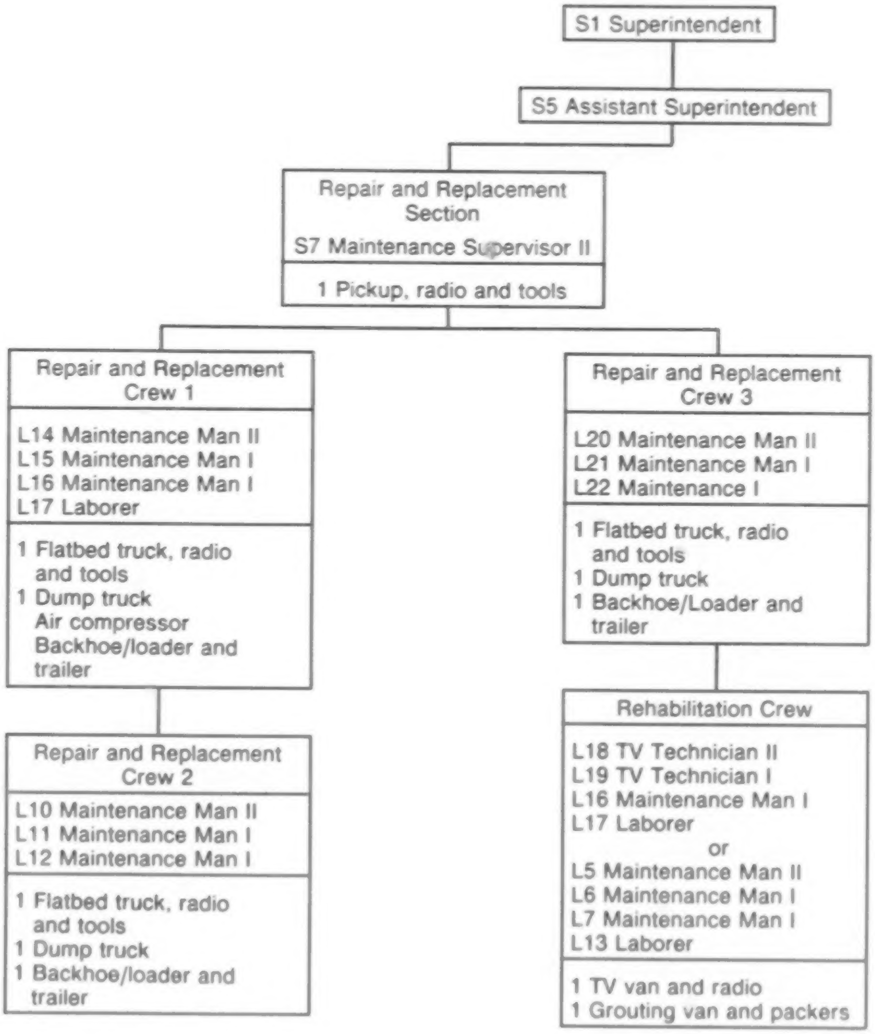
Equipment needs for this section are discussed in the following paragraphs and also in Chapter 7, Underground Repairs.

REPAIR UNIT. Equipment to install cleanouts, backwater valves, overflow valves, and to make repairs in rear easements will require a one-ton flatbed truck and hand tools. The truck should have tool compartments for small expensive tools that can be easily damaged, lost or stolen. Keep these tool compartments locked.

A partially fixed or sliding-top canopy which provides protection from the weather and working space on the job is very helpful. This type of truck should fit the particular needs of the agency to increase efficiency and at the same time to present a pleasing appearance.

NEW CONSTRUCTION UNIT. Well planned and well equipped construction trucks are necessary for an agency

TABLE 13.4 REPAIR AND REPLACEMENT SECTION ORGANIZATION


S1 Superintendent
S5 Assistant Superintendent
Repair and Replacement Section
S7 Maintenance Supervisor II
1 Pickup, radio and tools
Repair and Replacement Crew 1
L14 Maintenance Man II
L15 Maintenance Man I
L16 Maintenance Man I
L17 Laborer
1 Flatbed truck, radio and tools
1 Dump truck
Air compressor
Backhoe/loader and trailer
Repair and Replacement Crew 2
L10 Maintenance Man II
L11 Maintenance Man I
L12 Maintenance Man I
1 Flatbed truck, radio and tools
1 Dump truck
1 Backhoe/loader and trailer
Repair and Replacement Crew 3
L20 Maintenance Man II
L21 Maintenance Man I
L22 Maintenance I
1 Flatbed truck, radio and tools
1 Dump truck
1 Backhoe/Loader and trailer
Rehabilitation Crew
L18 TV Technician II
L19 TV Technician I
L16 Maintenance Man I
L17 Laborer
or
L5 Maintenance Man II
L6 Maintenance Man I
L7 Maintenance Man I
L13 Laborer
1 TV van and radio
1 Grouting van and packers

Note: The dump truck, air compressor, backhoe/loader are shared by all crews in the Section. The grouting van and packers will be rented when needed.

responsible for the maintenance and repair of any collection system. These trucks must be rugged and compact if they are to carry the number and variety of tools and materials required in emergency repairs or new construction work. An air compressor of sufficient capacity is the heart of all operations and is often carried at the rear of the cab. Outlets and piping for air can be placed around the truck body. Such a truck will be larger than a truck used to tow a trailer-mounted compressor. Locked compartments for small tools are highly desirable, as is a central space of sufficient size to permit transportation of lumber, pipe, cement shoring or other materials. Water tanks hung under the truck sides are desirable for use in mixing small quantities of concrete on the job. An electrical generator power take-off of sufficient voltage to permit operation of small electric tools or lights is very valuable.

ALL UNITS. Size and design of trucks are regulated by the requirements and by the money available to your agency. Trucks used by brick masons may be similar except that the bed should be divided into foot-high compartments in which sand, rock, bricks, and cement may be placed, and a space provided for the debris which must be hauled away after the job is completed.

Trucks used in the regular program of cleaning sewers can be similar to the trucks used for inspection except that the bodies should be longer to take care of larger tools and equipment needed for sewer scooters or large sewer balls and cones. Trailer hitches for towing cleaning trailers or dump trailers are essential. The sizes and arrangement of compartments will differ from the inspection truck, but the sliding canopy need not change.

As all of the trucks mentioned so far are required to stand or operate in fast-moving traffic or heavily traveled highways, they should be painted a bright color, with reflective striping across the rear portions. Amber blinking lights for night protection, roadway flares, and barricade light blinkers are a necessity. An electrical generator or power converter also is desirable when inspection lights and flood lights are needed, and outlets should be provided at a convenient location on the truck.

Whenever possible, all critical operating units should be equipped with two-way radio telephones or portable radio receivers and transmitter units. This will permit an emergency call to be dispatched and answered in a matter of minutes or within the hour of being received.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 456.

13.3S Why is a section of clear pipe a helpful training device?

13.3T What factors should be considered by Clearwater when trying to decide whether repair or construction should be done by the agency or by a private contractor?

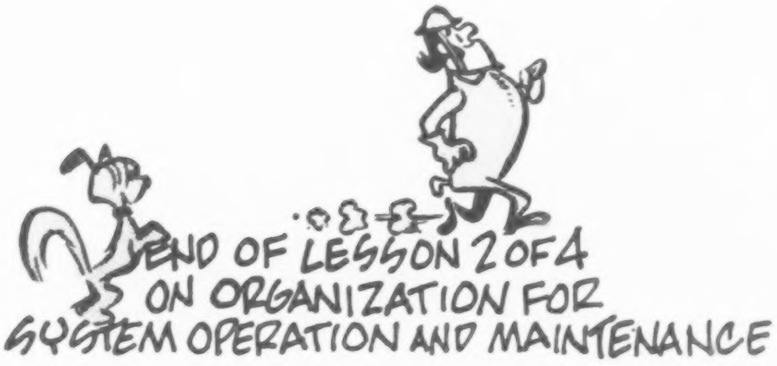
13.3U What is the difference between Clearwater's two units in the Repair and New Construction section?

13.3V What are the priority designations given repair work?

13.3W Work orders for new construction crews originate from what sources?

13.3X Closed-circuit television inspection will reveal what types of repair work?

13.3Y Where should small, expensive hand tools be kept in trucks?



DISCUSSION AND REVIEW QUESTIONS

Chapter 13. ORGANIZATION FOR SYSTEM OPERATION AND MAINTENANCE

(Lesson 2 of 4 Lessons)

Write the answers to these questions in your notebook before continuing. The problem numbering continues from Lesson 1.

6. What are the activities or duties of an emergency service crew?
7. What causes stoppages or blockages?
8. How would you determine the priority of job assignments for an emergency service crew?
9. Why are public relations important when an emergency service crew responds to a stoppage that floods a home?
10. Why should a field supervisor investigate emergencies?
11. How would you remove a stoppage in a sewer?
12. What would you do after a stoppage has been removed?
13. How would you attempt to evaluate the condition of a wastewater collection system?
14. What are the advantages of a training facility built with clear plastic pipe above ground?
15. What kind of work is done by a preventive maintenance crew?
16. How would you develop a priority list for scheduling preventive maintenance crews?
17. How would you determine whether or not to consider a private contractor for a sewer repair job?
18. What equipment is needed by repair crews and new construction crews?

WHAT · WHEN · HOW
WHERE · WHY · WHOSE ·

Chapter 13. ORGANIZATION FOR SYSTEM OPERATION AND MAINTENANCE

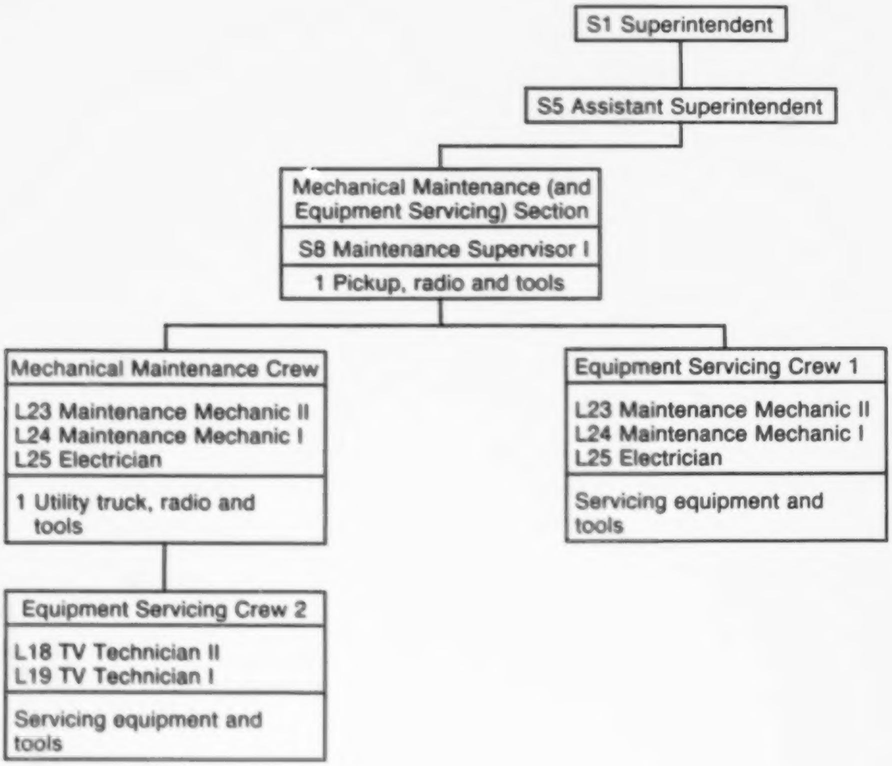
(Lesson 3 of 4 Lessons)

13.33 Mechanical Maintenance (and Equipment Servicing) Section

The Mechanical Maintenance (and Equipment Servicing) Section of Clearwater's Wastewater Collection System Division is primarily responsible for the inspection, maintenance and repair of the 16 wastewater lift stations in the collection system. The organization of the Section is shown by Table 13.5.

The Mechanical Maintenance Crew performs all the lift station activities. Since the superintendent does not expect the crew to use all its work time on this activity, the crew members' mechanical and electrical abilities will be used to service and make minor repairs to the mechanical and electrical equipment used by the other sections of the division. If and when more than expected time is required for lift station activities, the superintendent plans on either contracting for servicing of equipment or requesting additional personnel. The Mechanical Maintenance Crew becomes the Equipment Servicing Crew 1 when performing servicing activities.

TABLE 13.5 MECHANICAL MAINTENANCE
(and Equipment Servicing) SECTION


S1 Superintendent
S5 Assistant Superintendent
Mechanical Maintenance (and Equipment Servicing) Section
S8 Maintenance Supervisor I
1 Pickup, radio and tools
Mechanical Maintenance Crew
L23 Maintenance Mechanic II
L24 Maintenance Mechanic I
L25 Electrician
1 Utility truck, radio and tools
Equipment Servicing Crew 1
L23 Maintenance Mechanic II
L24 Maintenance Mechanic I
L25 Electrician
Servicing equipment and tools
Equipment Servicing Crew 2
L18 TV Technician II
L19 TV Technician I
Servicing equipment and tools

The TV Technicians will be used, when not operating the TV equipment or inspecting manholes, to service and make minor repairs to the TV equipment as an Equipment Servicing Crew 2.

13.331 Scope of Work

A review of the operation and maintenance of the Clearwater wastewater lift stations by the superintendent indicated existing procedures were fairly effective. Work priorities for this section are as follows:

- Respond to all lift station failures when notified by disatcher or by police department during off-duty hours,
- Assist other sections in setting up emergency pumps to prevent flooding of homes or businesses or by-passing of raw wastewater to drainage ditches,
- Respond to alarms from telemetered system,
- Perform all lift station maintenance except machine shop work which will be done immediately upon notice by local machine shops under contract with City of Clearwater,
- Perform work on preventive maintenance schedule and work requests from other sections, and
- Section supervisor to evaluate and establish a program that will change daily lift station inspections to a weekly inspection. Change will be accomplished by establishing a preventive maintenance program, a telemetering system, and increasing capacity of lift station auxiliary units such as oilers and reservoirs to operate for one month without service.

13.332 Lift Station Failures (Also see Chapter 8, Lift Stations)

A properly designed pump used in a wastewater lift station, although properly maintained, can fail to operate when least expected and usually when needed most. There are at least three reasons why a pump will fail to function. The pump may fail due to a malfunction in either the electrical system or in the mechanical system, or by debris plugging an impeller or jamming a check valve.

Electrical failure may be the result of a power failure or an outside power source being switched off due to a circuit overload on the main power source. A circuit breaker kick out due to a circuit overload in the station itself could cause an electrical failure. A quick check of the reset button or breaker switch could identify the electrical failure caused by an in-station overload kick out. When manual reset solves the problem temporarily but kicks out the reset or breaker switches (thermal overloads) again after a few moments of lift station operation, do not attempt to restart the pumps until a thorough inspection has been made of the pumping equipment in the lift station to find the problem. Correct the situation before attempting to restart.

When the problem has been located and corrected, reset the electrical breaker and put the lift station back on line. If the reset breakers kick out again, shut down associated equipment.

DO NOT ATTEMPT TO CORRECT THE ELECTRICAL PROBLEM UNLESS YOU ARE QUALIFIED AND AUTHORIZED BY YOUR AGENCY.

An overload may be caused by an electrical short in the motor or wiring control system, a mechanical part failure putting a load on the motor, or a plug in the impeller causing a load on the motor.

A mechanical failure could result from the breakdown of a bearing, poor shaft alignment, vibrations, mechanical seal failure, or malfunction of a mechanical float switch unit. Bearing failure can be noticed by a noise, vibration or heat. Other mechanical breakdown could be a malfunction in the check valves, air bubbler compressor, and switching units associated with the centrifugal pump.

In a pneumatic ejector lift station, mechanical problems are generally caused by a check valve malfunction on the intake or discharge pipe valves. Air compressor and control for air by-pass valves are other items which may fail. The shorting of the control electrode by grease or corrosion is another electrical problem found at times in pneumatic ejector stations, and the cycle timing device unit also can cause problems.

In the centrifugal pump, most failures are caused by debris piled up in the impeller area. Common material found in stopped impellers includes lodged sticks, wooden blocks, bricks, rocks, rags, mops, plastic bags, sacks, stringy material, and roots.

If a lift station cannot be put back on line before flooding occurs, emergency pumps should be set up and piping arranged to pump the station's influent from the wet well into the force main until the problem can be corrected.

13.333 Preventive Maintenance Schedule

A preventive maintenance schedule should be established to take care of every item in the lift station including lubricating the front door locks, replacing light bulbs and sweeping the floor. A very thorough and well-thought-out schedule that includes minor items will usually have provisions for maintenance of all the major pieces of equipment.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 456.

13.3Z What are the work priorities for Clearwater's lift station operation and mechanical maintenance section?

13.3AA How can Clearwater change the program of daily visits to lift stations to monthly visits without encountering problems?

13.3AB What are the major causes of lift station pump failures?

13.3AC What could cause an electrical failure?

13.3AD Under what circumstances may repair work on an electrical system be attempted?

13.334 Equipment

The Clearwater Mechanical Maintenance Crew will be furnished a one-ton truck equipped with a radio, utility body and an electric hoist capable of lifting medium weight equipment from lift stations. Heavy duty hoists or cranes will be rented to lift heavy equipment. Mechanical and electrical tools for maintaining lift stations, as described in Chapter 8, should be stored in the utility truck for use as needed.

Equipment and tools for servicing and making minor repairs to equipment used for operation and maintenance of a collection system are readily identified by maintenance mechanics and electricians. If not, a supplier of such equipment will be able to provide a list appropriate for the type of equipment to be serviced and repaired.

13.34 Inspection and Investigation Section

The Inspection and Investigation Section of the Wastewater Collection System Division of the City of Clearwater is responsible for inspection of the collection system (except lift stations) to determine the need for preventive maintenance, repairs and replacements. The section also inspects users of the facilities and manholes for indications of violations of the city's industrial waste and sewer-use ordinances, and investigates sources of excessive infiltration of groundwater and the inflow of storm water into the collection system. Table 13.6 shows the organization of the Inspection and Investigation Section.

13.341 TV Inspection

The need for closed-circuit television (CCTV) inspection of sewer lines arises when unidentifiable conditions are found by the activities of the Service Response and Preventive Maintenance Section and the Manhole Inspection and Infiltration/Inflow Crews. Requests for CCTV inspection of sewer lines are processed through the management information system and may result in work directives from the superintendent to the section supervisor. The supervisor is responsible for prioritizing work directives and their issuance to the TV Inspection Crew. The engineering division of Clearwater's Public Works Department may request CCTV inspection of new sewer line extensions which will be processed in the same manner.

The TV Inspection Crew leader is responsible for comprehensive CCTV inspection reports as described on page 205 in Section 5.432 of Chapter 5, Volume I. If the work directive calls for a video tape of a CCTV inspection, it will be made with a comprehensive voice description of what was observed on the TV screen during the inspection. Completed TV Inspection Reports will be submitted promptly to the section supervisor.

TV technicians will be trained to recognize and properly record the type and accurate location of the following examples of conditions that may adversely affect the operation and maintenance of a wastewater collection system:

- Crushed pipe, joint separation or offsets, faulty service connections, obstructions to flow or cleaning equipment, corrosion of concrete pipe, excessive sags in sewer lines, and root intrusions;
- Damage caused by excavation and construction adjacent to sewer lines;
- Unrecorded service connections that may indicate illegal use of a collection system;
- Infiltration and inflow sources and estimated amounts;
- Defects in repairs and new construction; and
- Evaluation of effectiveness of methods and equipment used for maintenance of problem sewer lines.

13.342 Infiltration/Inflow Investigation

The Service Response and Preventive Maintenance Section and the Manhole Inspection Crews have been trained to report observances of what they consider excessive infiltration of groundwater in a section of the collection system and the sources of storm water inflow. These reports will be processed through the management information system to produce work directives issued by the superintendent for investigations to be made by the Infiltration/Inflow Crew.

The Infiltration/Inflow Crew will make investigations as directed to determine the sources and amounts of infiltration and inflow using smoke and air testing and CCTV inspections when appropriate. Flow measurements will be made to determine the approximate amount of infiltration and inflow.

Smoke testing will be used to determine the following sources of storm water inflow:

- Building roof drains connected to a collection system,
- Storm water drainage systems connected to a collection system,
- Unsealed building sewer cleanouts at ground surface, and
- Cracked sewer pipes and leaking pipe joints (if the defective pipes and joints are not submerged in groundwater and cracks in the covering earth run from the pipes and joints to the ground surface).

Residents and occupants of buildings connected to the sewer lines to be smoke tested must be notified of the time the testing will be performed. The fire department servicing the test area must also be notified of the smoke testing. Smoke may enter a building through a plumbing fixture that has lost its water seal and someone could report a false alarm of a building on fire.

A report on a completed smoke test, including an accurate description of sources and location of storm water inflow, will be made daily and submitted to the section supervisor for appropriate follow-up action.

Directives for measuring the amount of groundwater infiltration into a collection system will be issued by the superintendent when a decision for repairing or replacing a section of sewer line is to be based on the determination of the amount of infiltration being excessive. The engineering section of the public works department will assist the Infiltration/Inflow Crew in the placement of flow measuring equipment if the amount of groundwater infiltration is suspected of being excessive.

Air testing of sections of sewer lines with excessive infiltration will be performed to determine the following sources of groundwater infiltration:

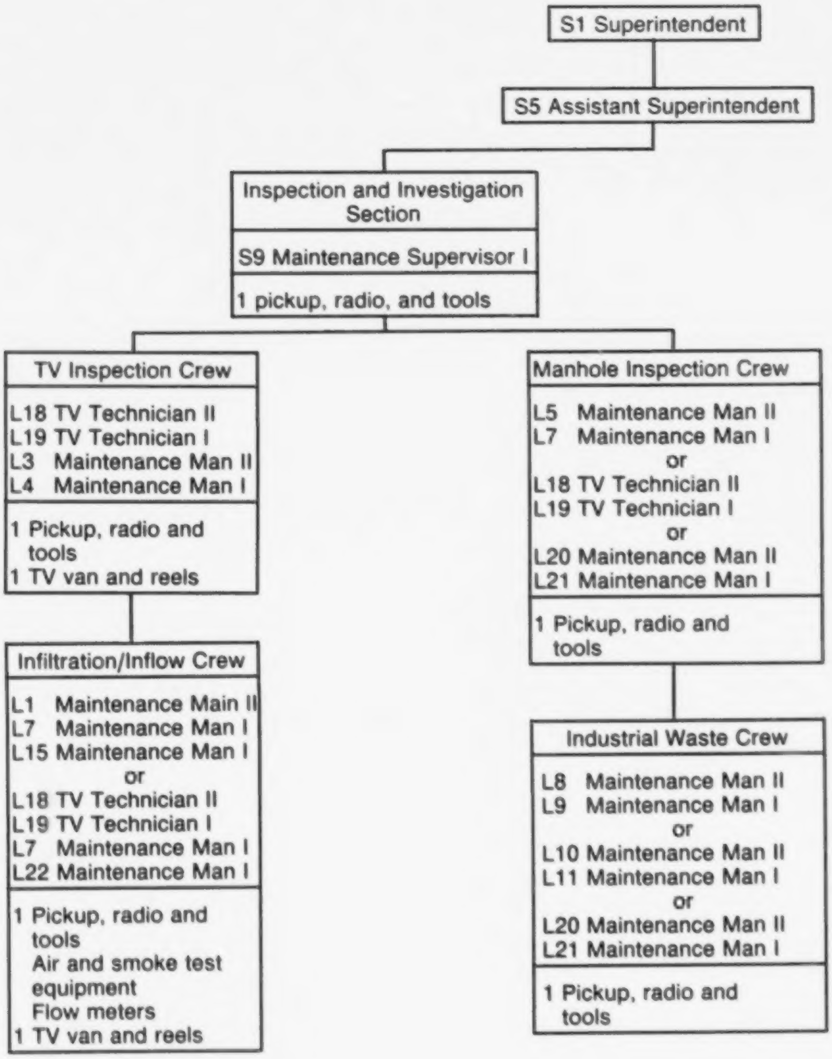
- Location of cracked pipe,
- Location of leaking pipe joints, and
- Location of leaking service connection.

Reports on air tests will be prepared by the crew leader, giving an accurate description and location of the sources of infiltration. Completed reports are to be submitted promptly to the section supervisor.

13.343 Manhole Inspections

Manholes, in sewer lines not cleaned at least annually, are

TABLE 13.6 INSPECTION AND INVESTIGATION SECTION


S1 Superintendent
S5 Assistant Superintendent
Inspection and Investigation Section
S9 Maintenance Supervisor I
1 pickup, radio, and tools
TV Inspection Crew
L18 TV Technician II
L19 TV Technician I
L3 Maintenance Man II
L4 Maintenance Man I
1 Pickup, radio and tools
1 TV van and reels
Manhole Inspection Crew
L5 Maintenance Man II
L7 Maintenance Man I
or
L18 TV Technician II
L19 TV Technician I
or
L20 Maintenance Man II
L21 Maintenance Man I
1 Pickup, radio and tools
Infiltration/Inflow Crew
L1 Maintenance Main II
L7 Maintenance Man I
L15 Maintenance Man I
or
L18 TV Technician II
L19 TV Technician I
L7 Maintenance Man I
L22 Maintenance Man I
1 Pickup, radio and tools
Air and smoke test equipment
Flow meters
1 TV van and reels
Industrial Waste Crew
L8 Maintenance Man II
L9 Maintenance Man I
or
L10 Maintenance Man II
L11 Maintenance Man I
or
L20 Maintenance Man II
L21 Maintenance Man I
1 Pickup, radio and tools

Note: Pickup trucks will be available from other sections as their crew personnel are assigned to this section.

to be inspected on an annual schedule to determine the condition of the manholes and the flow of wastewater through them. The section supervisor, after consultation with the Service Response and Preventive Maintenance Section supervisor to determine the frequency of sewer line cleaning, will determine the manholes to be inspected and will issue work directives to the Manhole Inspection Crew.

Inspection of manholes will be made from the ground surface using a high intensity light or a mirror if sunlight is available. The atmosphere in the manhole must be tested through any holes in the manhole cover or immediately after removing the cover. A manhole and sewer line inlets and outlets will be inspected for the following conditions:

- Presence of toxic or flammable gases;
- Cracks in the base, walls or joints of a manhole that indicate structural failure or infiltration of groundwater;
- Infiltration of groundwater into a manhole or indication of infiltration in a section of sewer line by an unaccountable increase in the depth of flow from an upstream manhole to a downstream manhole;
- Excessive offsets between the barrel sections and the cone and cover frame;
- Root intrusions into the manhole and inlet and outlet sewer lines;
- Accumulation of grease or debris in the invert of the inlet and outlet sewer lines;
- Strong odors and corrosion of the manhole walls and the upper parts of inlets and outlets of concrete sewer lines that may indicate the illegal discharge of industrial waste or of a septic condition of wastewater due to partial blockage of flow upstream of a manhole;
- Conditions of steps, if provided; and
- Firm seating of manhole cover in frame to prevent the rattling of the cover by vehicular traffic.

The crew leader makes a report for each manhole inspected using forms similar to those illustrated on page 186 in Section 5.37 of Chapter 5, Volume I. Reports are submitted daily to the section supervisor.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 456.

13.3AE What are the functions or responsibilities of the Inspection and Investigation Section of the Wastewater Collection System Division of the City of Clearwater?

13.3AF What types of conditions that may adversely affect collection system O & M TV Technicians be trained to recognize?

13.3AG Why must residents and the fire department be notified before an area of sewer lines is smoke tested?

13.344 Industrial Waste Inspections

Industrial waste inspections are made to verify compliance with the city's sewer-use and industrial waste ordinances. Samples of industrial waste discharges to the collection system are taken for analysis to determine compliance and to determine sewer-use charges. The Industrial Waste Crew performs the following work pursuant to directives from the section supervisor:

- Inspect and monitor discharges for violation of sewer-use and industrial waste ordinances. Look for activities and discharges that could damage the wastewater collection system or the processes and facilities at the wastewater treatment plant.
- Collect samples and deliver to laboratory at wastewater treatment plant.
- Locate sources of reported dumpings or by-passes that upset wastewater treatment process or are detected by collection system preventive maintenance crews. Make recommendations and provide evidence to person or agency responsible for issuing cease and desist orders to violators of sewer-use and industrial waste ordinances.

CEASE
AND
DESIST

For additional information see *PRETREATMENT FACILITY INSPECTION*, available from Ken Kerri, California State University, Sacramento, 6000 J Street, Sacramento, CA 95819-2694.

13.345 Inspection Equipment

Crews performing inspections and investigations of the Clearwater collection system will have the following special equipment:

- *TV VAN.* A typical closed-circuit television unit (TV Van) contains a colored television camera with a light and variable-sized skids, power and video cable, colored television screen, control unit, tape recorder, electrical generator, camera pulling cables and reels, footage counter, manhole pulleys, and a manhole-to-manhole communication system.
- *AIR TESTING* (for sewer line integrity). Air testing equipment consists of a trailer-mounted air compressor (shared with the Repair and Replacement Section), control unit, manhole and pipe segmenting plugs, and air hose and pulling rope reels. The equipment can be transported in a pickup truck.
- *SMOKE TESTING.* Equipment for smoke testing of sewer lines includes a gasoline- or electric-driven blower with a base fitting manhole cover frames, pipe plugs (or weighted canvas air curtains if flow in a sewer must be maintained), and smoke bombs.
- *FLOW METERING.* Wastewater flow metering equip-

ment consists of primary devices (weirs, flumes, floats and electronic sensors) placed in the wastewater flow and a mechanical or electronic recording unit.

- *OTHER*. Other essential equipment includes a small refrigerator for sample preservation, blowers, lights, meters for flow measurements, gas testing equipment, manhole lifters, small tools, safety harness, ladders, and portable field laboratory equipment. Field laboratory equipment includes pH meters, hydrogen sulfide test kits, various sample containers, composite samplers, and a portable electric generator. Field inspectors should be equipped with a radio-paging device that notifies them to phone the office.

13.346 Additional Essential Equipment

This section describes important pieces of equipment that should be readily available to all crews whenever the need arises. Collection system operation and maintenance equipment must be geared to 24-hour operation. Consequently, portable equipment must be ready to move at all times.

An air compressor is probably the most useful unit available to a crew because of the many pneumatic tools which it can power. The compressor should have a capacity of at least 150 CFM if two pavement breakers or clay spades are to be operated simultaneously. Whether the unit should be truck- or trailer-mounted depends on the size requirement.

Gasoline-powered wastewater pumps may vary in discharge diameter from 2 to 8 inches, depending on the size of the sewer to be serviced. Such pumps should be of the non-clogging type, trailer-mounted, preferably on four-wheel trailers for the larger sizes, and should be provided with a self-priming unit to save time and effort. Quick-coupling pipe or hose of sufficient length to pump wastewater between manholes or around a break is desirable. A small pneumatic pump makes a good unit to pump out flooded basements and to dewater trench excavations where high lifts are required and the volume is not large. Such a pump may be of either the ejector or centrifugal type. Plungers or low-speed suction pumps also are ideal to dewater trench excavations because their action is positive and constant.

Large portable generators are helpful for providing electricity to lift stations without standby generators during power outages or other electrical interruptions. Trailer- or skid-mounted generators can be transported easily by trucks or hydro-lift trucks. Special interlocking outlets must be provided at lift stations so the leads from the generator can be plugged into the proper socket to operate equipment during a power failure.

Good lighting must be available for work at night and also for warning purposes, including warning traffic and pedestrians. Lighting is essential because once repair of a broken line is started, work must continue without stopping until the line is repaired. Occasionally traffic conditions require certain work to be done at night.

Small portable generators are ideally suited to fill this need and, at the same time, they can be used to drive a variety of electrical tools. Where job requirements demand larger flood lights and more power, a trailer-mounted generator with a battery of flood lights can be used. When inspecting the interior of large sewers, storm drains, or appurtenant structures, a sufficient number of safe lighting units are needed. These units must be explosion-proof, double-insulated, and properly guarded or protected.

Blowers, either trailer-mounted or portable, eliminate any potential or real hazard which may exist in the form of toxic or explosive gases or oxygen deficiency. No inspection of sewers, storm drains or any confined spaces should be made unless proper ventilation is an accomplished fact and tests indicate *THE ATMOSPHERE IN WHICH YOU MUST WORK IS SAFE* from explosive conditions (LEL), toxic gases (hydrogen sulfide) and oxygen deficiency.

Trailer-mounted blowers with a capacity up to 7,500 CFM can easily ventilate many feet of medium size sewers. Small portable units that can be carried on a truck and powered by an electric generator or powered through a converter on the truck can provide sufficient air to ventilate any manhole, small pump pit or sump.

Two-way, portable telephone or radio units are most helpful when performing cleaning operations where sighting between manholes may be impossible. On heavily traveled streets it often is impossible for operators to hear each other or to see signals made by crew members. Flooding of basements can be prevented by stationing an operator and radio unit at a suitable location to advise the cleaning crew if a backup occurs. Night work often is required because of daytime traffic and quick, positive intercommunication is always available with radio units. Radio units used for communication by crews working in the field may be on a different radio frequency than the central dispatching system to avoid interference and confusion, provided the additional frequency is available. There are many other possibilities for radio use that can help you do your job quicker and safer.

A chemical spray unit may be very useful for insect and odor control.

A concrete mixer of 1/2-sack capacity will provide sufficient concrete for many jobs and can be stored and towed easily. For larger quantities of concrete, ready-mix concrete is probably less expensive. Many other items of equipment can add to the overall efficiency of your agency.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 456.

13.3AH Why are samples collected of industrial waste discharges to the collection system?

13.3AI Why is portable equipment necessary?

13.3AJ List some useful pieces of portable equipment.

13.35 Staff

Management of and support for collection system operators in the Wastewater Collection System Division of the City of Clearwater's Department of Public Works are provided by nine staff personnel including the superintendent. The organization of the staff is shown in Table 13.7.

13.351 Superintendent

The superintendent of the collection system division has the overall responsibility for the operation and maintenance of the system and duties include the following tasks:

- Supervises and coordinates, through section supervisors, the activities of operators and staff personnel;
- Compiles and analyzes planning and controlling reports (produced by a management information system, on manpower, material, and equipment utilization) for initiating actions to improve work efficiency;
- Recommends division policies that must be approved by a higher authority, establishes and reviews all other division policies regarding personnel practices, work methods, and safety procedures;
- Submits recommendations to Director of Public Works for additional personnel and new equipment;
- Periodically visits work sites to ensure use of correct, efficient, and safe work procedures;
- Provides technical assistance to, and assists in the training of, staff and operators;
- Prepares and submits budget requests and reports to the Director of Public Works;
- Approves acquisition of materials and equipment pursuant to budget authorization;
- Cooperates with the personnel department in employment of division personnel;
- Confers with the Director of Public Works (and other municipal and government officials when authorized by the director) to discuss adequacy, operation, and maintenance of the collection system;
- Cooperates with other city departments to coordinate efforts for improving standards of service and enforcement of plumbing codes and sewer-use ordinances; and
- Confers with the Director of Public Works and contractors to discuss expansion of collection system and construction materials and methods.

13.352 Assistant Superintendent

The assistant superintendent, in the absence of the superintendent, has the responsibility for operation and maintenance of the collection system, assists the superintendent, and has the following additional duties:

- Compiles data, analyzes maintenance reports and helps prepare reports regarding utilization of resources, work procedures, and safety;
- Assists in selection of new equipment and expansion of existing facilities;
- Visits job sites to ensure compliance with established work standards and safety procedures;
- Assists in preparing budget requests and reports;
- Confers with contractors and equipment suppliers to discuss bid specifications for services and equipment; and
- Directs maintenance of division personnel records and recommends promotions and pay increases.

13.353 Maintenance Supervisors

Maintenance supervisors direct the activities of the four sections of the wastewater collection system division with the Grade II supervisors directing the sections with the greater number of personnel and more complex work activities. The duties of maintenance supervisors include the following:

- Confer with the assistant superintendent to discuss work directives and scheduling, assignment of equipment, and evaluation of personnel performance;
- Visit work sites prior to assignment of crews and determine the best procedures;
- Assign work to crews and ensure that materials and equipment are provided;
- Give directives to and meet with crew leaders to assign work and to discuss prescribed work procedures;
- Visit work sites to periodically inspect and evaluate work in progress to assure that correct, efficient and safe work procedures are followed;
- Provide technical assistance and direct supervision of crews as needed for efficient conduct of work;
- Direct activities that are regarded to be sufficiently complex to require highly technical skills;
- Inspect and evaluate completed work to determine conformance with work directives and quality standards;
- Use maps and blueprints for directing work;
- Check equipment used by crews to ensure its efficient and safe operation and proper maintenance;
- Obtain work reports from crew leaders, make reports, and recommend improvements in work methods and service standards; and
- Train and instruct operating personnel.

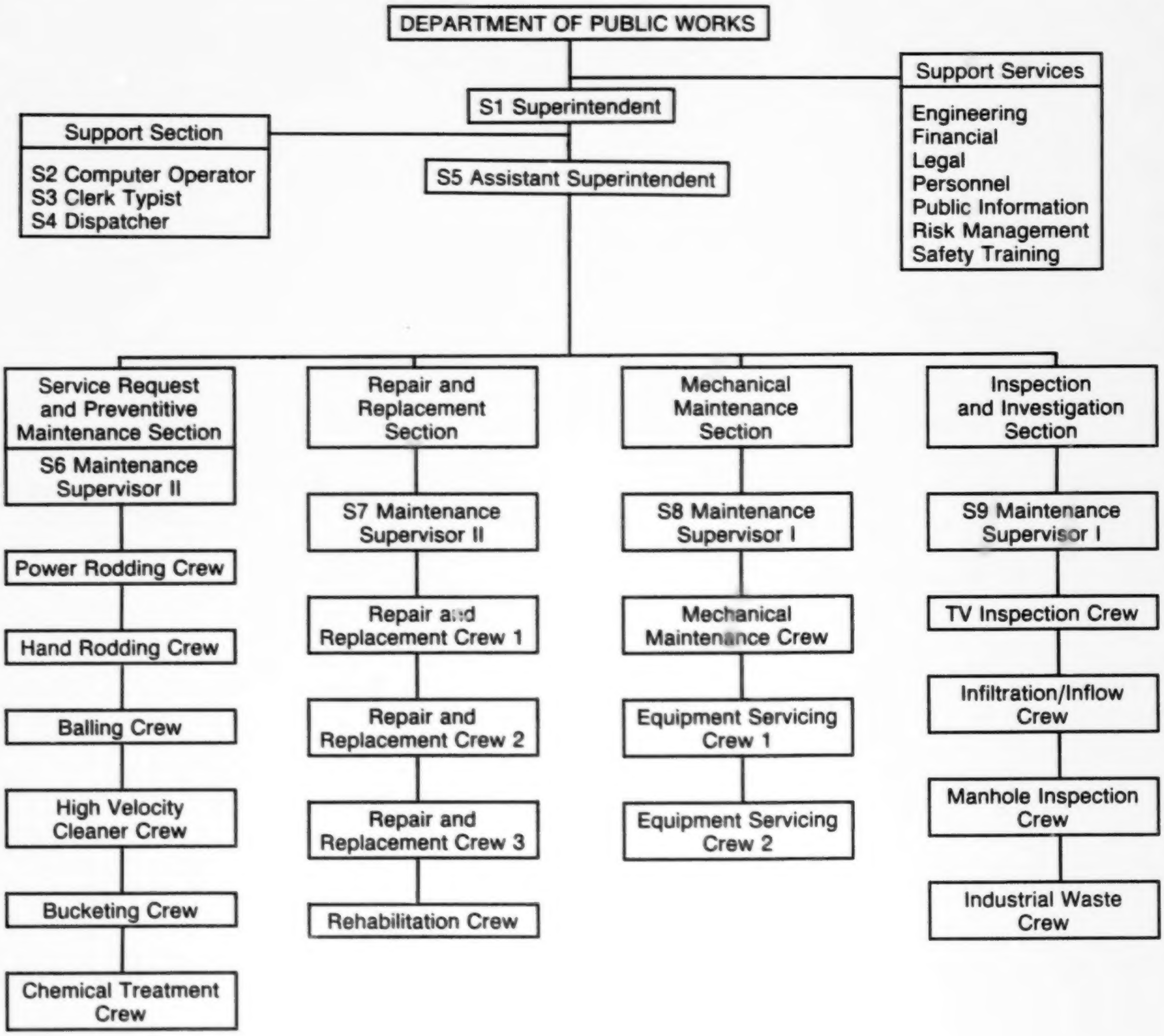
13.354 Support Services and Personnel

Due to the medium size of the wastewater collection system of the City of Clearwater and the number of management and collection system operators in the Collection System Division, many of the support services it requires are provided by the centralized support staff of the Department of Public Works and other city departments. The division has only a small support staff assigned directly to it as illustrated in Table 13.7.

SUPPORT SERVICES. The centralized support staff of the divisions includes the following groups which provide services to the collection system division:

- Engineering services for regulating the operation of the system, design and controls for new construction of sewers, drafting of sewer location maps, assistance for flow measurement, assistance in infiltration/inflow activities and expansion of system;
- Financial services for payroll, job and unit costing, and budgeting;

TABLE 13.7 ORGANIZATION OF CLEARWATER'S WASTEWATER COLLECTION SYSTEM DIVISION


DEPARTMENT OF PUBLIC WORKS
Support Services
Engineering
Financial
Legal
Personnel
Public Information
Risk Management
Safety Training
S1 Superintendent
Support Section
S2 Computer Operator
S3 Clerk Typist
S4 Dispatcher
S5 Assistant Superintendent
Service Request and Preventitive Maintenance Section
S6 Maintenance Supervisor II
Power Rodding Crew
Hand Rodding Crew
Balling Crew
High Velocity Cleaner Crew
Bucketing Crew
Chemical Treatment Crew
Repair and Replacement Section
S7 Maintenance Supervisor II
Repair and Replacement Crew 1
Repair and Replacement Crew 2
Repair and Replacement Crew 3
Rehabilitation Crew
Mechanical Maintenance Section
S8 Maintenance Supervisor I
Mechanical Maintenance Crew
Equipment Servicing Crew 1
Equipment Servicing Crew 2
Inspection and Investigation Section
S9 Maintenance Supervisor I
TV Inspection Crew
Infiltration/Inflow Crew
Manhole Inspection Crew
Industrial Waste Crew

- Legal services for contracting (for construction, equipment rental, and services), claims defense and personnel administration;
- Personnel services for employment of division personnel, provision of employee benefits, development of personnel policies and practices, and resolution of personnel grievances;
- Public information services for advising collection system users of the services provided by the division and need to adequately finance its operations, advising affected public on inconveniences to be caused by division activities and advising all users of the policies concerning services provided by the division;
- Risk management services include advice on safe operating and work procedures, processing of damage claims, accident investigations, and provision of insurance; and
- Safety services for establishment of safety policies and procedures, safety equipment acquisition and assistance in safety training.

SUPPORT SECTION. The staff personnel in the support section and their activities include the following:

- Computer Operator. Performs basic computer programming, loads acquired specialty software into computers, enters information from work reports into a computer's data base, uses a computer to process data for preparation of planning and controlling reports, assists other staff personnel in use of computers, and assists other support personnel in their activities.
- Clerk Typist. Operates office equipment, serves as a secretary to superintendent, acts as receptionist for division, compiles personnel data used by other divisions, maintains internal personnel records, maintains division files, answers telephone, and maintains internal financial records.
- Dispatcher. Dispatches division crews to service request and work sites as directed by section supervisors, answers telephone to receive requests for service, locates sites of problems using sewer location maps, determines location and status of service response crews, transmits this information to appropriate section supervisor by radio or telephone, maintains records on service requests and responses, maintains log of crew location and status, processes authorization for street cuts and records status of repavement, maintains sewer location maps for support staff and section crews, and assists the clerk typist.

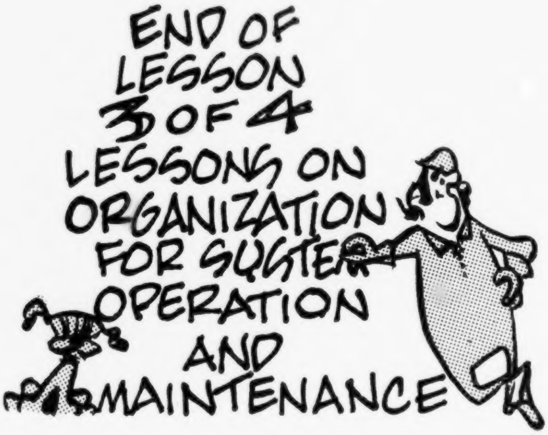
QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 456.

13.3AK List the major duties of a collection system superintendent.

13.3AL List the major support services needed by a collection system division.

13.3AM What kinds of support activities can be performed by a computer operator?



DISCUSSION AND REVIEW QUESTIONS

Chapter 13. ORGANIZATION FOR SYSTEM OPERATION AND MAINTENANCE

(Lesson 3 of 4 Lessons)

Write the answers to these questions in your notebook before continuing. The problem numbering continues from Lesson 2.

19. Why do larger organizations have a special section or unit for lift station operation and mechanical maintenance?
20. How would you develop a work priority list for a lift station?
21. What kinds of failures can occur in a lift station?
22. What are the tasks or jobs for an industrial waste section in a wastewater collection system agency?
23. How would you develop a work priority list for an industrial waste section?
24. What kind of equipment is needed by an industrial waste section?

Chapter 13. ORGANIZATION FOR SYSTEM OPERATION AND MAINTENANCE

(Lesson 4 of 4 Lessons)

13.4 SAFETY CONSIDERATIONS

Today's stringent safety requirements established by OSHA have had a direct influence on the amount of staffing required to perform almost all of our various maintenance activities. Increasing concern and enforcement exist today by local, state, and federal safety agencies to insure that collection system operators obey required safety regulations. Less than full compliance with these safety regulations is unacceptable. Supervisors must recognize and accept this responsibility. Chapter 11 documents the dismal safety record of our profession. Every agency must recognize the benefits of an effective safety program that protects employees and *PREVENTS ACCIDENTS*. Every agency, supervisor and operator has both a social responsibility as well as a legal responsibility to comply with safety regulations and to enthusiastically support your safety program.

You must have an established and regularly scheduled safety program including the following:

- Traffic Control. Requirements for providing adequate traffic control to safeguard the motoring public, as well as your own operators, can have considerable influence on the amount of staffing required (see Chapter 4, Section 4.3, Routing Traffic Around Job Site, pages 116 to 124, Volume I).
- Shoring. Strict compliance to existing shoring requirements, which must be met at all times, also can require additional staffing on certain excavation projects (see Chapter 7, Section 7.2, Shoring, pages 375 to 393, Volume I).
- Confined spaces. The latest safety requirements relative to people working in confined spaces, including manholes, would appear to make the two-operator crew obsolete. Such requirements indicate two operators are needed on the ground surface (besides the operator in the manhole) in order to be capable of physically removing the operator in the manhole when

and if an emergency arises (see Chapter 4, Sections 4.4, 4.5, 4.6 and 4.7 on manhole entry procedures, pages 124 to 153, Volume I).

Throughout this section we have made constant reference to two-operator crews. How can you operate two-operator crews and still protect the safety of operators? In most cases, it is possible. All of our maintenance procedures are designed to minimize the need for an operator to enter a manhole. This is especially true of two-operator crews and the work to which they are assigned. On those occasions when it becomes necessary for one of the two operators to enter a manhole, a supervisor is called to act as the third operator. This procedure can work very well. It is certainly a more acceptable alternative than to require all crews to consist of three operators.

13.5 REORGANIZATION

Changing activities of a wastewater collection system division due to the aging of the system, changes in use, and expansion of the system being operated and maintained, along with an observed need to increase the efficiency by changing procedures can create a need for reorganization of equipment and personnel.

The organization of a collection system division should be reviewed periodically using standards for efficient organizations and reorganization proceedings should be initiated if appropriate. A superintendent should involve the division personnel affected by the reorganization in the planning process and not create disturbances by too frequent reorganizations.

There will be constraints on reorganization including personnel resistance to change, physical limitations, and personnel classifications and compensation.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 457.

13.4A How have safety requirements influenced the amount of staffing required to perform maintenance activities?

13.4B What has been the impact of safety requirements on the two-operator crew?

13.5A What are the factors that may limit the reorganization of a collection system agency?

13.6 SCHEDULING MAINTENANCE

Collection systems are designed to transport wastewater without interruption to disposal sites or treatment plants. Most collection systems are designed to be "self-cleaning." Experience has shown otherwise for many collection systems. As time passes, various conditions develop which interrupt flows and diminish the design capacities and efficiency of collection systems.

Inadequate maintenance procedures have resulted in overflows or discharges of polluted wastewater into streams, streets, right of ways, rivers, and private property. Supervisors have been able to excuse these conditions as "unavoidable accidents," "acts of God or nature" or lack of sufficient capacity within their systems. Today, environmental concerns and regulatory agencies will no longer accept these excuses or tolerate these conditions. Also, the public accepts fewer inconveniences and demands to know what went wrong and why.

The responsibility for elimination of these conditions rests squarely on today's collection system supervisors. They must realize that they CAN influence the performance of the collection system. Through the use of modern, specialized maintenance equipment, microcomputers, and well planned maintenance scheduling, the supervisor can develop meaningful maintenance programs that will minimize or eliminate these undesirable conditions.

13.61 Types of Maintenance

Although there are many types of maintenance and many different thoughts regarding what is a good maintenance program, let's try to think in terms of what needs to be done. A good maintenance program tries to anticipate what is going to go wrong and prevent it from happening. If something goes wrong, the problem is identified and corrected or repaired. With these ideas in mind, let's try to schedule maintenance crews on the type of maintenance job they are doing.

13.611 Emergency Maintenance

Even with all our modern equipment and sophisticated maintenance programs, emergency maintenance is still a basic service provided by maintenance organizations. With a well trained and equipped crew, emergency service can be very efficient. When emergencies do arise, generally they are handled swiftly and with little or no inconvenience to the public. When major structural damage occurs from earthquakes, landslides, or erosion and the collapse of pipes from corrosion damage, it usually takes a little longer to restore service.

Naturally we cannot schedule emergency maintenance. We can only plan to handle it quickly and effectively. As our preventive maintenance scheduling techniques develop and improve, the need for emergency maintenance will be constantly decreasing.

13.612 Preventive Maintenance

Preventive maintenance is the most effective and efficient type of maintenance program. Preventive maintenance should be a total concept including all the aspects of this chapter. A good preventive maintenance program requires a supervisor who knows what is likely to happen and where. The supervisor needs accurate, functional maps, good records, and an understanding of how to apply and use them. Intelligent use and assignment of available staff and equipment is important, as is properly planned and meaningful maintenance scheduling. All these aspects, properly applied, will provide a true preventive maintenance program.

An effective preventive maintenance program will enable the supervisor to apply effective preventive and corrective maintenance procedures over a controlled time period which will keep the collection system operating as intended with a minimum of stoppages or failures. The goal of a preventive maintenance program is to improve existing conditions in problem areas to a point where scheduled maintenance can be significantly reduced or ultimately reduced to the absolute minimum.

THE PROGRAM ALLOWS THE SUPERVISOR TO MANAGE THE COLLECTION SYSTEM, RATHER THAN HAVE THE COLLECTION SYSTEM MANAGE THE SUPERVISOR.

The program is effective, efficient, and economical. The results to be achieved can become a matter of pride to all operators involved in making such a program work—from the supervisor to the collection system operator.

13.62 Basic Aspects of Scheduling

To formulate an effective schedule for maintaining a collection system can be very difficult. Scheduling is complex, not necessarily in a technical sense, but more because of the many varied facts and details that must be considered. There are no shortcuts to good scheduling. Maintenance of a collection system is an ongoing process which often spans years of past history, and which must consider future years of anticipated growth and increased loadings on collection systems. It is difficult to list all the many details to be encountered in planning a maintenance schedule. Some basic details to be concerned with are described in the following section.

13.621 Knowledge

This is the name of the game. Without it, there is little chance for the schedule to be effective. The knowledge needed is not necessarily relative to anyone's intelligence or IQ. The required knowledge will be more relative to the collection system and also the maintenance procedures and equipment. Required knowledge includes the following:

- Collection system. You must have a thorough knowledge and understanding of your collection system. You will need to know the nature of your problems and the areas in which they are concentrated.

  There are various ways of acquiring this information. A great deal of it may come to you through experience and familiarity with your collection system. The most reliable information could come from a data-based management information system such as the one described in Section 12.7 of Chapter 12, page 363.

  Aside from these obvious sources of information, there are other steps you can take:

  a. Complete a comprehensive study of your system. Locate and identify the areas that are creating the most problems. After you have determined your problem areas, try to locate and identify specific problems.

  b. A most effective method of identifying and locating specific problems is by selective manhole inspection and TV inspections. Emphasis should be placed on the term "selective." Haphazard or random inspections, particularly with TV, can be wasteful and inefficient.

     This practice can be used to survey even the smallest collection system. By careful pre-selection of troublesome areas, TV inspection can be performed in an economical manner by a contract service.

- Maintenance procedures and equipment. Any schedule you plan will be influenced by, and perhaps tailored to, the procedures and equipment available to you. You should carefully evaluate these procedures and equipment. Elsewhere in this course you have learned that certain procedures and equipment are most effective when used to combat specific problems. Others may be effective to some degree in coping with a variety of problems. How are you using available equipment? Are you using it to its fullest potential?

13.622 Timing

Of vital importance to any schedule is proper timing. The very word "schedule" suggests timing. When planning maintenance schedules, two important time factors should be considered.

- Only when needed. The ideal time schedule for maintenance would provide for completion of needed maintenance just prior to the development of any problems or emergencies. In actual practice this is virtually impossible to attain. It is in fact, however, what we should be striving to achieve to the greatest degree possible.

- Too frequent. If there is one weakness common to many maintenance schedules, this would be it. In their efforts to foresee and forestall the development of emergency situations, many supervisors are prone to scheduling maintenance too frequently. This approach cannot be considered to be totally wrong. It is the lesser of two evils, the other being an inadequate schedule which results in too little maintenance. At best, however, too frequent maintenance must be considered inefficient. It is inefficient from an economical standpoint and it ties up operators and equipment that could be used more productively in other areas where maintenance or repairs are needed.

13.623 Adjusting Schedules

A good maintenance schedule should be flexible. Periodically it should be revised in accordance with the results it has or has not produced.

- Objectives. When an area or section of line is assigned to a maintenance schedule, it should be with an objective in mind. Will the scheduled maintenance eventually eliminate the problem? Will the scheduled maintenance merely control the problem to a degree that is acceptable? After five years of scheduled maintenance, is there any significant improvement evident? If not, what is the next step?

- Effectiveness. When a schedule has been designed with an objective in mind, it is possible to measure the effectiveness of that schedule by the degree to which you have achieved your objective.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 457.

13.6A How can overflows or discharges of polluted wastewater into streams, streets, right of ways, rivers, and private property be minimized or eliminated?

13.6B What is a preventive maintenance program?

13.6C How would you prepare an effective schedule for maintaining a wastewater collection system?

13.6D How does a person gain knowledge of or become familiar with a collection system?

13.6E What time factors should be considered when developing a maintenance schedule?

13.6F On what basis should maintenance schedules be adjusted?

13.63 Examples of Scheduling

Every agency needs to develop a scheduling procedure that will provide an effective preventive maintenance program for its wastewater collection system. Two examples of effective preventive maintenance scheduling are set forth in the following sections.

13.631 Sacramento County, California

Sacramento County, California uses the following procedures for scheduling preventive maintenance of its 2,300 miles of lateral, main, trunk and interceptor sewers.

INDIVIDUAL LINES. Individual lines between manholes are maintained on the following schedules:

- An individual line is initially scheduled for cleaning the day after removal of a stoppage in the line,
- The individual line is then scheduled for a TV inspection four months after the initial cleaning,
- If roots were the cause of the stoppage, the individual line is scheduled for cleaning on a 12-month frequency,
- If a grease accumulation was the cause of the stoppage, the individual line is scheduled for cleaning on a six-month frequency,
- The frequency of an individual line cleaning is either decreased or increased if the preceding cleaning indicates a need for a change, and

- When the frequency between cleaning of an individual line exceeds five years, it is removed from the preventive maintenance schedule.

SECTIONAL LINES. All individual lines within a designated section of the collection system are maintained on the following schedules:

- If the lines within a section have more than one stoppage per 7,000 feet of lines predominately in easements or one stoppage per 20,000 feet of lines predominately in streets, all lines in the section are scheduled for cleaning on a 12-month frequency; and
- If the number of stoppages within a section drops below the above stoppage rates, all lines in the section are removed from the preventive maintenance schedule.

COORDINATION. The scheduling of individual line cleaning is coordinated with the cleaning of all lines in a section so that individual lines will not be cleaned more often than they would be under an individual line cleaning schedule.

MICROCOMPUTER APPLICATION. Microcomputers and specialty software are used to facilitate the preventive maintenance scheduling in the following manner:

- Information from reports on line cleaning, inspection, repairs and replacement work are entered into a computerized data base using specialty software to create a maintenance history for all individual lines in the collection system;
- Microcomputers, data base, and specialty software are used by supervisors to produce planning and controlling reports;
- The reports are then used by the supervisors to schedule individual line and sectional line preventive maintenance based on the guidelines previously described; and
- Supervisors enter the preventive maintenance schedules into the computer's data base and use specialty software for the weekly production of work orders from the data base.

PERFORMANCE EVALUATION. Sacramento County, California, using the preventive maintenance scheduling procedures previously described, has reduced the number of stoppages in 2,300 miles of lateral, main, trunk and interceptor sewer lines to approximately 380 per year.

13.632 Santa Clara County, California

Santa Clara County Sanitation District No. 4 uses a computerized system, given the acronym COSMO, for scheduling the preventive maintenance of the 290 miles of lateral, main, and trunk sewers in the district's wastewater collection system. Conceptually, COSMO performs as shown in Figure 13.3 with the four principal elements being the Data Base, Criteria, Analysis Program, and Scheduler.

Note the similarity of the COSMO information flow schematic to the Management Information System schematic shown in Figure 12.7 in Chapter 12, page 365. The "External Data" and "Analysis Reports" in the COSMO schematic are the same as "Work Reports" and "Reports for Planning & Controlling" respectively in the Management Information System schematic. A microcomputer and specialty software process data and prepare analysis reports, preliminary and final preventive maintenance schedules.

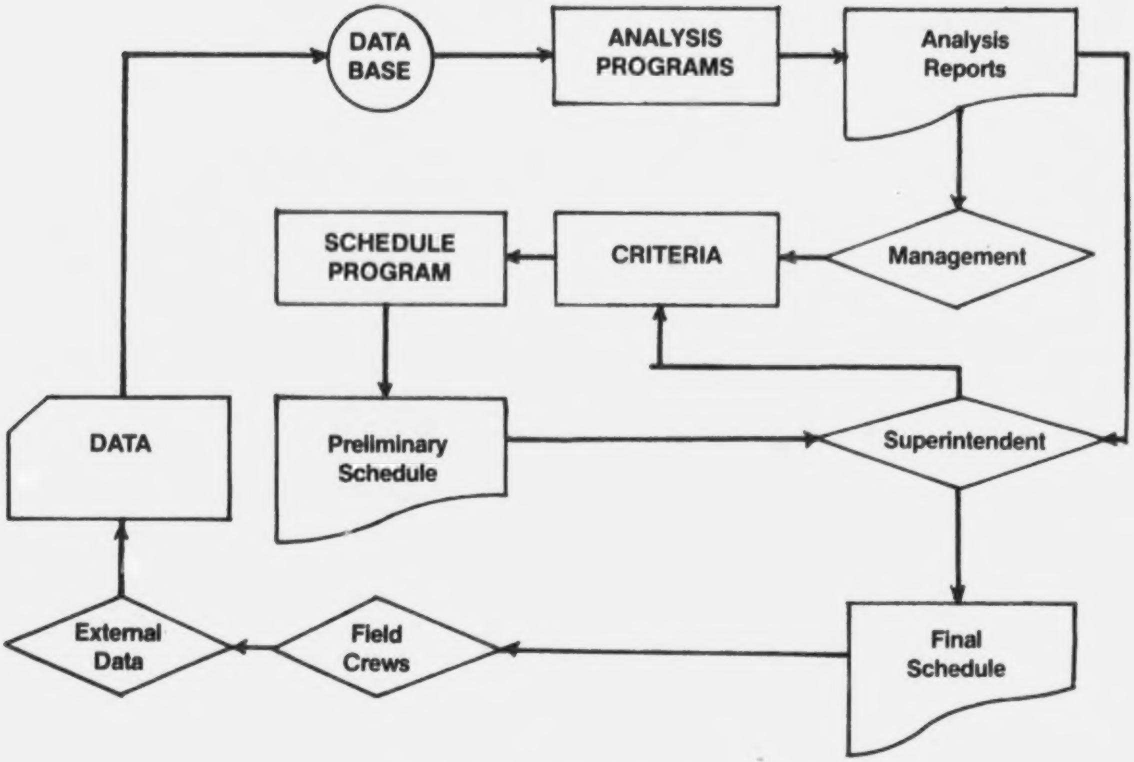


Fig. 13.3 COSMO information flow schematic

DATA BASE. The Data Base contains information on the collection system's physical characteristics as well as previous cleaning, repair, replacement and TV inspections. The data are derived from the maintenance crews' work reports and are filed by sewer line segments between manholes.

CRITERIA. The criteria are a set of goals and objectives of the preventive maintenance program of the district translated into a form used by a digital computer. The Criteria also include a set of operational rules that govern the logic used by the Scheduler.

ANALYSIS PROGRAM. The Analysis Program provides informational reports on performance of the preventive maintenance work activities of the district's crews. The performance reports can be produced for the collection system as a whole, sections or individual lines.

SCHEDULER. The Scheduler prepares a cleaning schedule based on the Criteria. With the aid of external factors and the computer Scheduler program, the superintendent's clerical assistant prepares a monthly schedule of preventive maintenance work for the district's crews.

DEBRIS SEVERITY. Debris Severity is one of the data items reported by cleaning crews and is a measure of how much debris was in a sewer line segment at the time it was cleaned. Debris severity, S, may be reported as a number 0 to 4. The numbers relate to the following debris conditions:

$S = 0$, line was clear of debris
$S = 1$, line contained a mild amount of debris
$S = 2$, line contained a moderate amount of debris
$S = 3$, line contained a severe amount of debris
$S = 4$, stoppage of flow in line.

CLEANING FREQUENCY. The objective of the district's preventive maintenance scheduling is to clean each line segment when its debris severity reaches the moderate level, $S = 2$. The Criteria component of the COSMO software can be manipulated to establish a correlation between the latest reported debris severity for a line segment, the latest cleaning interval, and the projected time to the next scheduled cleaning. The Cleaning Frequency presently being used by the district is shown in Table 13.8.

For example, if a line segment was reported to have a mild Debris Severity, $S = 1$, when it was cleaned on April 1, 1986 and it had been previously cleaned on March 16, 1985, the line segment will be scheduled for cleaning during the month of December, 1987. From March 16, 1985, to April 1, 1986 is 12.5 months. 1.75 (from Table 13.8) times 12.5 months equals 21 months. April 1, 1986 plus 21 months gives December 1987.

SCHEDULING. The Scheduler component of the COSMO software projects monthly cleaning assignments based on a priority which is dependent on the Debris Severity reported at the latest cleaning, the elapsed time between the last two

TABLE 13.8 CLEANING FREQUENCY USING CLEANING HISTORY

LATEST DEBRIS SEVERITY	SCHEDULING FREQUENCY
S = 0 (Clear)	$\Delta T = 2.0 \times T$
S = 1 (Mild)	$\Delta T = 1.75 \times T$
S = 2 (Moderate)	$\Delta T = 1.0 \times T$
S = 3 (Severe)	$\Delta T = 0.75 \times T$
S = 4 (Stoppage)	$\Delta T = 0.5 \times T$

cleanings, and the amount of time that would elapse if the line segment was cleaned as scheduled. Postponing the scheduled cleaning increases the priority and cleaning earlier than scheduled decreases the priority. The Scheduler uses the priority values to arrange line segments scheduled for cleaning in order of importance for any given month.

The Scheduler makes monthly line segment cleaning assignments until the sum of the projected cleaning time for the lines (using the time required for the latest cleaning of the lines) is equal to the hours the district's superintendent has allocated for cleaning during a given month. When the Scheduler tries to make an assignment to a month that has reached its allocated time, the line segments with the lowest priorities are re-scheduled in a subsequent month. This process is continued until all line segments have been scheduled and the manpower allocations are satisfied for each month.

The scheduling process takes place each month and the superintendent uses the printed schedules to make daily work assignments. Since the district's line segments are identified by the location of their upstream and downstream manholes on sewer maps and monthly cleaning schedules are printed in manhole number sequence, the superintendent can group line segments in localized areas for daily work assignments.

PERFORMANCE EVALUATION. One guideline of effectiveness of the preventive maintenance scheduling process used by Santa Clara Sanitation District No. 4 is a mathematical method shown in Figure 13.4. Your goal will be to schedule cleaning of lines when they reach a debris severity of about two. This will mean that they get cleaned before sewer debris accumulations cause a stoppage but not so often that you're working on relatively clean lines.

$$SD = \left[\frac{\sum_{i=1}^{M} (S_i - 2)^2}{M}\right]^{05}$$

Insert in line S_i = Debris severity of any line cleaned $(0 \le S_i \le 4)$

WHERE: M = Number of lines cleaned in a given period,

S_i = Debris severity of any line cleaned $(0 \le S_i \le 4)$, and

SD = Measure of effectiveness.

NOTE: To calculate the "Measure of effectiveness, SD," for a preventive maintenance scheduling program, perform the following steps.

1. Collect the data for all lines cleaned during a given time period. For each line cleaned, assign a debris severity value from 0 (clear of debris) to 4 (cleaned after a stoppage occurred. The debris severity value is the value S_i the formula. The subscript "i" identifies each line. "i" has a value of 1 for the first line cleaned, 2 for the second line cleaned and so on until the last lined cleaned has a value or number represented by the letter "M" which could be 87, indicating that 87 lines were cleaned during the time interval.
2. Take each S_i value, subtract 2 from each value, square the difference and repeat this procedure for every line cleaned.
3. Σ means that we add up or sum up all of the squared differences.
4. Divide the total or sum of the squared differences by the number of lines cleaned, "M".
5. Take the square root of the value obtained in step 4.
6. The result gives a value for SD, a measure of the effectiveness of the preventive maintenance scheduling program.

Fig. 13.4 Preventive maintenance scheduling effectiveness measure

To illustrate the use of the measure of effectiveness, if sewer lines were only cleaned after stoppages occurred, S_i would equal 4 and SD would equal 2. The same value of SD would result if every line was clear of debris when cleaned ($S_i = 0$). If all lines cleaned had a Debris Severity of two and no stoppages occurred during a given time period, the SD would equal zero. The optimum measure of effectiveness (SD = 0) of a preventive maintenance scheduling process is impractical to reach considering the unpredictable nature of wastewater collection systems. It is more important to follow the trend of the measure of effectiveness and make appropriate adjustment to the scheduling criteria when an adverse trend occurs.

The mathematical measure of effectiveness of the district's preventive maintenance scheduling since it started using a computer and the COSMO software is shown in Figure 13.5. Note the gradual downward trend in the measure of effectiveness towards the ideal value of 0.

Figure 13.5 also shows that the district has been able, by the use of computer-aided scheduling, to reduce the annual amount of sewer line cleaning from 1,140,000 feet for the 12 months ending June, 1983, to 544,000 feet for the 12 months ending June, 1986, while only seeing an increase in line stoppages from approximately 20 to 40 during that same period in the 290 miles of sewer lines. Having cleaned the most severe lines, the district is now concentrating its line cleaning activities on approximately 37 percent of the lines in its collection system that are accumulating debris nearly at the optimum "moderate" rate.

QUESTIONS

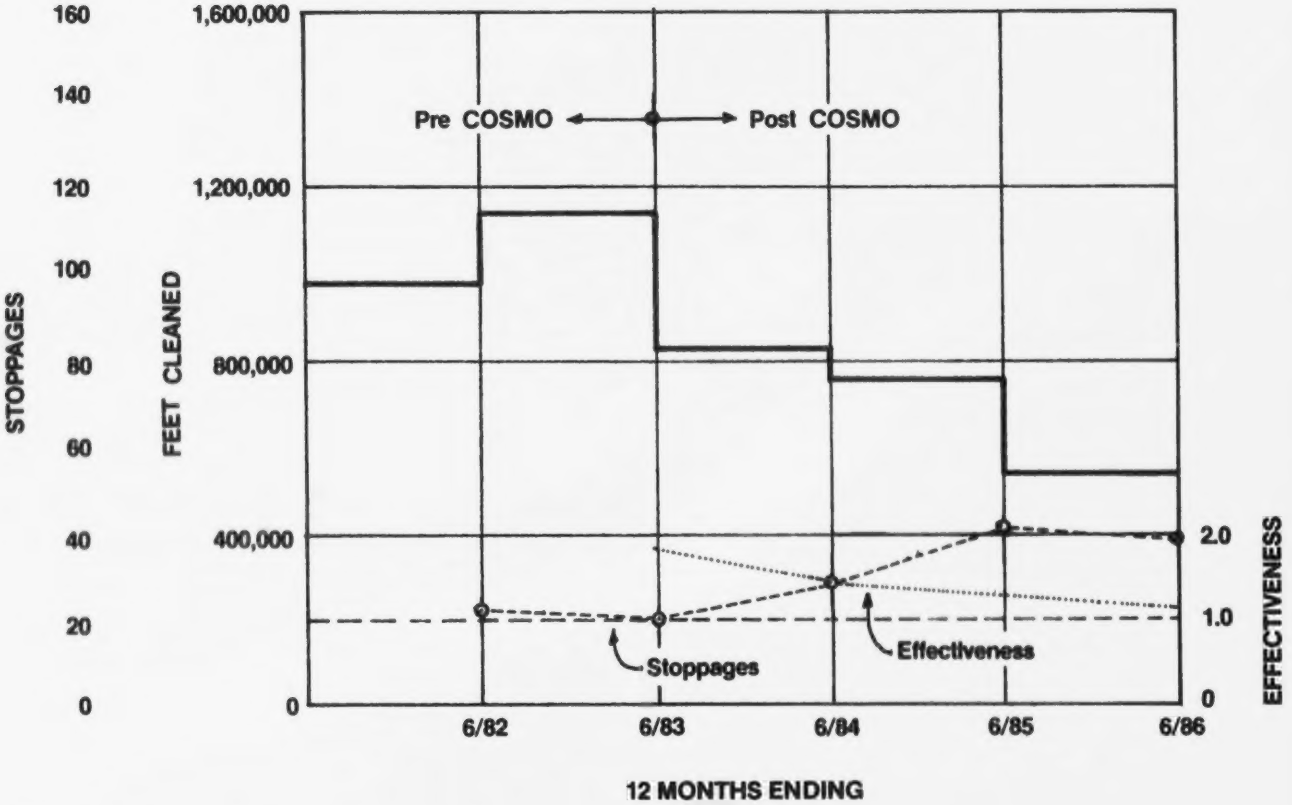
Write your answers in a notebook and then compare your answers with those on page 457.

13.6G What is Sacramento County's cleaning schedule for individual sewer lines?

13.6H What types of reports are prepared by Santa Clara County's specialty software?

13.6I What information is in Santa Clara County's data base?

13.6J How does Santa Clara County determine the cleaning frequency of sewer lines?



NOTE: The dotted "Effectiveness" line is gradually dropping towards the optimum value of "0" on the effectiveness scale

Fig. 13.5 Five-year preventive maintenance performance by Santa Clara County Sanitation District No. 4

13.7 GENERAL PERFORMANCE INDICATORS

This section outlines a procedure for calculating two indicators of performance for operation and maintenance of sewer lines and lift stations in a wastewater collection system. The indicators are based on the objective of minimizing the following:

- Number of stoppages per mile of sewer line,
- Number of failures per lift station, and
- Cost of maintenance of sewer lines and lift stations.

SEWER LINES. To calculate the Performance Indicator for sewer lines, the following information must be known:

- Length of sewers in miles,
- Annual cost of operating and maintaining sewers, and
- Annual number of stoppages that caused flooding.

Sewer line stoppages of concern should include only those stoppages that caused flooding. Flooding is defined in terms of wastewater overflowing manholes or backing up in service lines and flooding a home or business. If a sewer backs up to the extent that a plumbing fixture in a home will not drain, this event is considered a stoppage that causes flooding (of a plumbing fixture). Stoppages cleared before flooding occurs are not counted because they have not caused a threat to public health. Overflows resulting from insufficient sewer capacity should also be counted because they signal the need for immediate corrective action and are a potential threat to public health.

EXAMPLE 1

Calculate the Performance Indicator for the sewers in a collection system consisting of 1500 miles of sewers that spent $2,000,000 in one year and had 125 stoppages.

KNOWN		UNKNOWN
Length of sewers, miles	= 1500 miles	Performance Indicator
Annual expenditures	= $2,000,000	
Annual number of stoppages	= 125 stoppages	

Calculate the Performance Indicator for the sewers.

$$\text{Performance Indicator} = (\text{Costs, \$/mile})(\text{Stoppages, number/mile})$$

$$= \frac{\$(2{,}000{,}000)}{(1500\text{ miles})}\ \frac{(125\text{ stoppages})}{(1500\text{ miles})}$$

$$= 111$$

This procedure can be repeated every year to evaluate the performance of the collection system and the effectiveness of the preventive maintenance program. By plotting the results on an annual basis, trends in performance can be revealed.

A trend over several years will be more meaningful if the cost of maintenance used each year is based on the value of a dollar at the beginning of the trend period. This can be done by applying the inflation rate from the beginning year to each given year.

Since the objectives include minimizing the number of stoppages and the costs or expenditure, the SMALLER the Performance Indicator, the better the job you are doing. In order to show improvement by an increasing trend, a Performance Rating can be used.

EXAMPLE 2

Calculate the Performance Rating for the sewers in the collection system in Example 1.

KNOWN		UNKNOWN
Performance Indicator	= 111	Performance Rating
Assumed Standard	= 90	

Calculate the Performance Rating for the sewers.

$$\text{Performance Rating} = \frac{(\text{Standard})(100\%)}{\text{Performance Indicator}}$$

$$= \frac{(90)(100\%)}{111}$$

$$= 81\%$$

Any standard may be assumed that best helps you illustrate the performance of the sewers in your collection system. The same standard should be used every year. This is a very useful technique for justifying budgets, increase in staff and more equipment.

LIFT STATIONS. To calculate a Performance Indicator for the lift stations in a collection system, the following information is needed.

- Number of lift stations,
- Annual cost of operating and maintaining lift stations (including energy costs),
- Annual number of lift station failures, and
- Total energy consumed by all lift stations in millions of kilowatt hours.

Lift station failures of concern should include only those failures that caused flooding. Do not consider an alarm reported by a telemetry system as a failure unless flooding actually occurs. If a lift station is properly monitored and the telemetry system is designed to prevent flooding, record only failures that result in actual flooding and a threat to public health. If a power outage occurs and standby power or emergency plans are not activated soon enough or are not effective enough to prevent flooding, then this is considered a lift station failure.

The formulas for calculating lift station Performance Indicators and Performance Ratings are as follows:

$$\text{Performance Indicator} = \frac{(\text{Costs, \$/station})(\text{Failures, number/station})}{\text{Energy Consumed, million kwh/station}}$$

$$\text{Performance Rating} = \frac{(\text{Standard})(100\%)}{\text{Performance Indicator}}$$

Any appropriate Standard may be assumed for your lift stations. If your lift stations experienced no failures during a particular year, one failure must be assumed in order to go through the calculations.

This section has illustrated how to calculate Performance Indicators and Performance Ratings for sewers and lift stations. These ideas may be applied to other objectives such as minimizing the number of service requests or complaints. If other collection system agencies are similar to yours and collect data the same way, you could compare your performances. For more details on the development and use of Performance Indicators, see Section 13.8, "Additional Reading," reference 7, "Performance Indicators for Wastewater Collection Systems."

13.8 ADDITIONAL READING

1. *MANAGEMENT OF LOCAL PUBLIC WORKS,* Interna-

tional City Management Association, 1120 G Street, N.W., Washington, D.C. 20005. Price, $37.95.

2. *MANPOWER REQUIREMENTS FOR WASTEWATER COLLECTION SYSTEMS IN CITIES AND TOWNS UP TO 150,000 IN POPULATION,* Manpower Development Staff, Office of Water Program Operations, U.S. Environmental Protection Agency, Washington, D.C. 20460.
3. *MANPOWER REQUIREMENTS FOR WASTEWATER COLLECTION SYSTEMS IN CITIES OF 150,000 TO 500,000 IN POPULATION,* Manpower Development Staff, Office of Water Program Operations, U.S. Environmental Protection Agency, Washington, D.C. 20460.
4. *RECRUITMENT, RETENTION AND UTILIZATION OF PERSONNEL IN WASTEWATER COLLECTION SYSTEMS IN CITIES AND TOWNS WITH POPULATIONS UP TO 150,000,* Whate, Katie A., Municipal Permits and Operations Division, Office of Water Program Operations, U.S. Environmental Protection Agency, Washington, D.C. 20460.
5. *PLANT MANAGER'S HANDBOOK,* MOP SM-4. Available from Water Pollution Control Federation, 601 Wythe Street, Alexandria, VA 22314-1994. Order No. MSM4OHO. Price, members, $28.00; others, $34.00.
6. "Management of an Effective Collection System Maintenance Program," by John Brady and Ken Kerri, Deeds & Data, Water Pollution Control Federation, December 1975.
7. "Performance Indicators for Wastewater Collection System", by John Brady, Steve Goodman, Ken Kerri and Robert Reed, Journal WPCF, Vol. 51, No. 4, p. 695, April 1979.
8. "Computerization of Sewer Maintenance Scheduling," by James R. Schaaf, *PUBLIC WORKS,* p. 128, September, 1985 and p. 64, October, 1985.
9. *THE SUPERVISOR AND THE JOB* by Aaron Q. Sartain and Alton W. Baker, McGraw-Hill Book Company, 8171 Redwood Highway, Novato, CA 94947. Price $35.96.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 457.

13.7A Performance indicators can be used to work towards what types of objectives?

13.7B What information must be known to calculate a "Performance Indicator" for sewer lines?

END OF LESSON 4 OF 4 LESSONS
ORGANIZATION FOR
SYSTEM OPERATION AND MAINTENANCE

DISCUSSION AND REVIEW QUESTIONS

Chapter 13. ORGANIZATION FOR SYSTEM OPERATION AND MAINTENANCE

(Lesson 4 of 4 Lessons)

Write your answers to these questions in your notebook before continuing with Objective Test on page 458. The problem numbering continues from lesson 3.

25. What circumstances could create a need for reorganization of equipment and personnel?

26. What is a preventive maintenance program?

27. What kinds of work are done by an emergency maintenance crew?

28. How would you schedule collection system maintenance crews?

29. How would you evaluate the effectiveness of your maintenance programs?

30. How would you develop an organization to operate and maintain your wastewater collection system?

SUGGESTED ANSWERS

Chapter 13. ORGANIZATION FOR SYSTEM OPERATION AND MAINTENANCE

ANSWERS TO QUESTIONS IN LESSON 1

Answers to questions on page 411.

13.1A Determining the type of personnel and equipment needed to perform the work of an organization begins with a clear statement of the organization's mission, goals and objectives. Then a detailed list of work to be performed is prepared and activities are grouped by similarities. Personnel and equipment needs can then be defined for each work activity.

13.1B Crew members should work together and perform the same type of work for an extended period of time to become familiar with each other and their work in order to become an efficient team.

13.1C The two main effects of delegating authority are (1) frees management to plan and direct, and (2) allows decisions to be made by people closest to the situation and most directly affected by the decision.

13.1D To hold a person accountable for his or her actions, three factors must *ALL* be present:

1. The individual must know what he or she is supposed to do,
2. The individual must know how to accomplish assigned tasks, and
3. The individual must have control of the factors that regulate what he or she is doing.

Answers to questions on page 421.

13.2A The major work tasks performed by a collection system agency include:

1. Service requests,
2. Preventive maintenance,
3. Repair and replacement,
4. Mechanical maintenance,
5. Inspections and investigations, and
6. Indirect activities.

13.2B Crews tend to specialize in larger systems because there are more crews and each crew is more apt to do a similar job every day, thus becoming specialists in the jobs they do most frequently.

13.2C The basic crew in most maintenance organizations is the emergency crew.

13.2D Emergency crews usually consist of two operators. Under these conditions, neither operator should ever enter a manhole unless a third person is available.

13.2E Other activities conducted by an emergency crew when there are no emergencies include inspection, repair, map checking, location of inflow/infiltration, and scheduled maintenance jobs.

13.2F The number of operators on a balling crew and the extent to which they are used is determined by the conditions under which the crew must work. Important conditions include traffic conditions and the quantity of material to be removed from the sewer.

13.2G Balling crews also can function as a repair crew, chemical crew, bucket machine crew, or smoke testing crew.

13.2H High velocity cleaners are commonly used all of the time.

13.2I No, CCTV equipment available today can be operated effectively by existing collection system operators with adequate training.

13.2J Crews should be rotated from job to job so trained crews are available at all times for any job and so crew members can be transferred from one crew to another if a key operator in one crew becomes ill or the opportunity for promotion develops.

13.2K Smoke testing crews try to locate and identify points of inflow and illegal connections.

13.2L Repair crews usually deal primarily with replacement of defective portions of the collection system, while construction crews usually are engaged in new work.

ANSWERS TO QUESTIONS IN LESSON 2

Answers to questions on page 423.

13.3A Priority responses to requests for emergency services are as follows:

1. Flooded home or business,
2. Manhole overflowing,
3. Manhole cover off,
4. Cleanout overflowing, and
5. Home service backed up.

13.3B When multiple emergency calls are received, the field supervisor evaluates the problems, assigns priorities, redirects service crews and requests assistance from field preventive maintenance crews for specific equipment or assistance in handling calls as necessary.

Answers to questions on page 425.

13.3C When a private home becomes flooded with wastewater, try to remove the cause of flooding and assist the people living in the home to clean and remove articles which may have been damaged or will be damaged if left in place.

13.3D To minimize legal problems resulting from flooding:

1. Find the cause and location of the backup to identify who is responsible,
2. Follow procedures approved by legal department, and
3. Act quickly to reduce damages.

13.3E Flooding problems resulting from a low service connection can be corrected by installing and maintaining a backflow preventer and an overflow valve.

13.3F Service requests to recover valuable property from a sewer may be handled by a preventive maintenance crew; however, responses to such requests should be handled in accordance with agency policy.

Answers to questions on page 426.

13.3G En route to a problem area, the crew begins to fill out a service request form and locates the appropriate area map. Upon arrival, the dispatcher is informed of time of arrival and location of unit.

13.3H The location of a main line stoppage is determined by inspecting manholes in a downstream flow direction until a manhole is located with reduced flow or no flow. The stoppage is located between this manhole and the next upstream manhole.

13.3I Stoppages are usually removed by using hand tools. If this procedure fails, power equipment such as a high velocity cleaner or a power rodder is used.

13.3J The first job a crew does upon arrival to clear a service line stoppage is to inspect the main line to be sure it is open and flowing.

13.3K A service line blockage is cleared by removing the cleanout cover and running a hand rod with a 2 or 3½-inch auger down the cleanout to the main line. If this doesn't work, the problem is the resident's. If there is no cleanout, the resident should have a plumber inspect the line. If the plumber finds the line clear from the home to the property line, it is the agency's problem. The line may have to be dug up to be cleared. A cleanout should be installed to facilitate clearing any future stoppages.

13.3L After clearing a service line that had to be dug up, the Service Request Form and Repair Request Card must be completed.

13.3M If a new cleanout is required, it should be installed by the repair and replacement crew.

Answers to questions on page 427.

13.3N A priority list should be developed for scheduling work by preventive maintenance crews to provide an organized approach for solving problems and insuring the completion of necessary jobs.

13.3O Clearwater developed the following priority list:

1. Assist emergency service crews,
2. Clean lines where stoppages occur within three days after the stoppage has been cleared,
3. Schedule power rodder in root problem areas to minimize root stoppages,
4. Schedule high velocity cleaner in grease problem areas to minimize grease stoppages,
5. Assign cleaning crews to areas of collection system to be cleaned this year,
6. Construct training facility and provide training sessions,
7. Develop priority list of collection system to be inspected by closed-circuit television, and
8. Prepare and schedule program to chemically treat sewers with serious root problems.

13.3P During the preparation and scheduling of a chemical treatment program for root control, you should:

1. Review research literature,
2. Visit communities with similar problems and evaluate their root control programs,
3. Select two methods and field test in advance of full-scale root control program, and
4. Keep records of all aspects of program.

Answers to questions on page 429.

13.3Q The major disadvantages of using a bucket machine include potential damage to the lines and a time-consuming operation.

13.3R High velocity cleaners are probably the most effective cleaning tools for removing grease, grit, sand, gravel, and debris.

Answers to questions on page 434.

13.3S A section of clear pipe is a helpful training device because crews can observe the effectiveness of the cleaning equipment, its limitations, and how to use it as safely and efficiently as possible.

13.3T Items to be considered when trying to decide whether an agency should do a repair or new construction job or a private contractor should do the work include:

1. Cost of materials,
2. Time to complete job, and
3. Special safety or construction equipment required.

13.3U The difference between the two units is that one does mainly repair work in easements that usually only require hand tools, and the other does new and repair work in open areas where mechanical equipment such as backhoes may be used.

13.3V Priority designations given repair work are (1) immediate repair, and (2) repair when time available.

13.3W Work orders for new construction come from requests by emergency service and preventive maintenance crews processed through appropriate channels. Building permits are sometimes required.

13.3X Closed-circuit television inspection will reveal repair work consisting of the following:

1. Bad taps,
2. Bad joints,
3. Offset joints,
4. Broken pipes, and
5. Deteriorated pipe.

13.3Y Small, expensive hand tools should be kept in locked compartments in trucks.

ANSWERS TO QUESTIONS IN LESSON 3

Answers to questions on page 437.

13.3Z Work priorities for Clearwater's lift station operation and mechanical maintenance section are as follows:

1. Respond to lift station failures,
2. Assist other sections in setting up emergency pumps to prevent flooding and by-passes,
3. Respond to alarms from telemetered system,
4. Perform regular lift station maintenance,
5. Perform work on preventive maintenance schedule and work requests from other sections, and
6. Supervisor to evaluate and establish a program that will change lift station inspections from daily to monthly.

13.3AA Clearwater can convert lift station visits from daily to monthly by establishing a preventive maintenance program, installing a telemetering system, and increasing the capacity of lift station auxiliary units such as oilers and reservoirs to operate for one month without service.

13.3AB The major causes of lift station pump failures include malfunctions in the electrical or mechanical systems, or by debris plugging an impeller or jamming a check valve.

13.3AC An electrical failure may be the result of a power failure or an outside power source being switched off due to circuit overload on the main power source.

13.3AD Repair work on an electrical system may be attempted only if you are qualified and authorized to do the work.

Answers to questions on page 440.

13.3AE The function or responsibility of the Inspection and Investigation Section is to inspect the collection system (except lift stations) to determine the need for preventive maintenance, repairs and replacements. The section also inspects users of the facilities and manholes for indications of violations of the city's industrial waste and sewer-use ordinances, and investigates sources of excessive infiltration of groundwater and the inflow of storm water into the collection system.

13.3AF Conditions that may adversely affect collection system O&M that must be recognized by TV Technicians include crushed pipe, joint separation or offsets, sags, root intrusion; damage caused by excavation and construction; unrecorded service connections; infiltration and inflow; defects in repairs and new construction; and evaluation of effectiveness of methods and equipment used for maintenance of problem service lines.

13.3AG Residents and the fire department must be notified before an area of sewer lines is smoked to avoid someone mistaking smoke from a sewer as a building fire and reporting a false alarm.

Answers to questions on page 441.

13.3AH Samples are collected of industrial waste discharges to the collection system for analysis to determine compliance and to determine sewer-use charges.

13.3AI Portable equipment must be readily available for all crews when they need it for jobs throughout the service area.

13.3AJ Useful pieces of portable equipment include air compressors, gasoline-powered wastewater pumps, small portable generators, blowers, and two-way portable telephone or radio units.

Answers to questions on page 444.

13.3AK The major duties of a collection system superintendent include supervising and coordinating activities, compiling and analyzing planning and controlling reports, recommending policies, submitting recommendations for personnel and equipment, visiting work sites, providing technical assistance, preparing and submitting budget recommendations, approving acquisition of materials and equipment, cooperating with personnel department, conferring with officials regarding system O&M, cooperating with other departments, and conferring with contractors to discuss construction and expansion.

13.3AL Support services needed by a collection system division include engineering, financial, legal, personnel, public information, risk management and safety.

13.3AM A computer operator performs basic computer programming, loads acquired specialty software into computers, enters information from work reports into a computer's data base, uses a computer to process data for preparation of planning and controlling reports, assists other staff personnel in use of computers, and assists other support personnel in their activities.

ANSWERS TO QUESTIONS IN LESSON 4

Answers to questions on page 446.

13.4A Safety requirements have required increases in the amount of staffing.

13.4B Safety requirements prevent either person on a two-operator crew from entering a manhole. On those occasions when it becomes necessary for one of two operators to enter a manhole, a foreman can be called to act as a third operator.

13.5A The constraints to reorganization include personnel resistance to change, physical limitations, and personnel classifications and compensation.

Answers to questions on page 448.

13.6A Undesirable conditions caused by overflows and discharges of wastewater can be minimized or eliminated by the use of modern, specialized maintenance equipment and well planned maintenance scheduling.

13.6B A preventive maintenance program is a total concept that includes functional maps, good records and intelligent use and assignment of available staff and equipment. Scheduling of maintenance activities is well planned and meaningful. The objective of preventive maintenance is to improve existing conditions in problem areas to a point where scheduled maintenance can be significantly reduced or ultimately eliminated.

13.6C To prepare an effective schedule for maintaining a wastewater collection system, a knowledge of the collection system, maintenance procedures, and available equipment and manpower are very important. Actual maintenance schedules must attempt to schedule jobs only when needed. Effectiveness of the maintenance program must be continuously evaluated and schedules adjusted as necessary.

13.6D A person can become familiar with a collection system by studying maps and records; actual field experience is very important too.

13.6E Important time factors that must be considered when developing a maintenance program are: (1) when the work will be needed and (2) how frequently maintenance needs to be performed.

13.6F Maintenance schedules should be adjusted in accordance with the results the schedule has or has not produced.

Answers to questions on page 451.

13.6G Sacramento County schedules individual sewer lines for cleaning according to the following guidelines:

1. An individual line is initially scheduled for cleaning the day after removal of a stoppage in the line,
2. If roots were the cause of the stoppage, the individual line is scheduled for cleaning on a 12-month frequency,
3. If a grease accumulation was the cause of the stoppage, the individual line is scheduled for cleaning on a six-month frequency,
4. The frequency of an individual line cleaning is either decreased or increased if the preceding cleaning indicates a need for a change, and
5. When the frequency between cleaning of an individual line exceeds five years, it is removed from the preventive maintenance schedule.

13.6H Reports prepared by Santa Clara County's specialty software include analysis reports, preliminary and final preventive maintenance schedules.

13.6I Information in Santa Clara County's data base includes the collection system's physical characteristics as well as previous cleaning, repair, replacements and TV inspections.

13.6J The cleaning frequency of sewer lines is scheduled when the line's debris severity value reaches the moderate level, S = 2.

Answers to questions on page 453.

13.7A Performance indicators can be used to work towards objectives of minimizing:

1. Number of stoppages per mile of sewer line,
2. Number of failures per lift station, and
3. Cost of maintenance of sewer lines and lift stations.

13.7B To calculate the "Performance Indicator" for sewer lines, the following information must be known:

1. Length of sewers in miles,
2. Annual cost of operating and maintaining sewers, and
3. Annual number of stoppages that caused flooding.

OBJECTIVE TEST

Chapter 13. ORGANIZATION FOR SYSTEM OPERATION AND MAINTENANCE

Please mark the correct answers on an answer sheet as directed at the end of Chapter 1. There may be more than one correct answer to the multiple choice questions.

TRUE-FALSE

1. Every effort should be made to prevent emergencies from occurring in collection systems.
   1. True
   2. False
2. Homeowners should be allowed to connect their sewers from their new homes into existing lateral sewers.
   1. True
   2. False
3. Stoppages do not have to be cleared quickly because the wastewater usually backs up in the sewer.
   1. True
   2. False
4. Requests for recovering valuable items from sewers such as jewelry should be handled according to agency policy.
   1. True
   2. False
5. Problem areas located in sewers by a TV unit can be video taped for review and selection of a solution to the problem.
   1. True
   2. False

MULTIPLE CHOICE

Questions six through ten relate to a supervisor's responsibilities for planning, organizing, staffing, directing, and controlling a wastewater collection system.

6. Planning requires supervisors to determine
   1. Alternative solutions to a problem,
   2. Data to be collected and analyzed.
   3. Policies for collection system O&M.
   4. Which operators should be hired.
   5. Who should do what work.
7. Organizing requires supervisors to
   1. Decide who does what work.
   2. Delegate authority.
   3. Determine goals.
   4. Issue orders and instructions.
   5. Take corrective action as necessary.
8. Staffing requires supervisors to
   1. Decide who does what work.
   2. Determine if there are enough qualified collection system operators to fill available positions.
   3. Provide opportunities for advancement.
   4. Recruit new operators.
   5. Train operators.
9. Directing requires supervisors to
   1. Decide who does what work.
   2. Hire new operators.
   3. Issue orders and instructions.
   4. Motivate operators.
   5. Supervise operators.
10. Controlling requires supervisors to be sure
    1. Authority is delegated to operators.
    2. Corrective action is taken as necessary.
    3. Essential activities are performed.
    4. Objectives are achieved as planned.
    5. Progress is being made towards objectives.
11. Stoppages in sewers may be caused by
    1. Broken pipes.
    2. Debris.
    3. Grease.
    4. Joint failure.
    5. Roots.
12. Lift station failures include
    1. Controller failure.
    2. Electrical circuit failure.
    3. Failure to pump wet well dry after each pumping cycle.
    4. Odor failure.
    5. Pump failure.
13. Organization charts are helpful to show
    1. How the collection system agency is organized.
    2. How to locate sewers.
    3. The chain of command of an agency.
    4. The structure of an agency.
    5. The way to select solutions to problems.
14. How does an emergency service crew try to remove a stoppage?
    1. Balling
    2. Hand rods
    3. Flushing
    4. Parachutes
    5. Tell homeowner to stop dumping grease into sewer
15. A sewer-use ordinance should specify who does the
    1. Enforcement.
    2. Monitoring.
    3. Regular cleaning of the main lines.
    4. Regular repairing of broken pipe.
    5. Regular sealing of leaky joints.
16. Potential problems in a wastewater collection system include
    1. Grease.
    2. Inflow, infiltration and/or exfiltration.
    3. Odors.
    4. Old, deteriorated pipe.
    5. Roots.

17. Which of the following items should be included in an inventory of a *WASTEWATER COLLECTION SYSTEM?*
    1. Condition of collection system
    2. Estimate of sizes and lengths of sewers
    3. Number of pump parts in warehouse
    4. Number of trucks
    5. Safety statistics

18. Under what conditions might a private contractor be considered to do a sewer job?
    1. A long time is required to complete job
    2. Material for job is costly
    3. Necessary crews are not available
    4. Required safety equipment is not available
    5. Special equipment is required

19. The advantage of having an emergency service crew supervisor inspect emergency service requests (complaints) include
    1. Contact with the public by an experienced supervisor.
    2. Keeps supervisor in contact with crews.
    3. On-the-spot evaluation of the problem by a supervisor.
    4. Selection of a solution and procedure to solve the problem by an experienced supervisor.
    5. There are no advantages.

20. Some *CRITICAL FACTORS* that should be considered when developing the structure of a wastewater collection system agency include
    1. Existing and potential problems.
    2. How to keep the power rodder operating every day.
    3. Need for an above-ground clear plastic pipe training facility.
    4. Responsibility of agency.
    5. Size of wastewater collection system.

21. Objectives of a modern wastewater collection system organization could include
    1. Ability to respond quickly to an emergency service request and provide the necessary service.
    2. Minimizing number of stoppages per mile of sewer.
    3. Minimizing odor complaints.
    4. Minimizing unnecessary expenditures.
    5. Solving unemployment problems in the community.

22. Typical duties of an industrial waste section include
    1. Attempting to locate and/or identify sources of wastes that upset wastewater treatment plants.
    2. Balling sewers filled with grease from restaurants.
    3. Collecting data and making recommendations regarding industries that violate sewer-use ordinance.
    4. Collecting samples of discharges into collection system.
    5. Inspecting discharges into collection system.

23. How can a closed-circuit television unit with video tape help to evaluate the *CONDITION* of a wastewater collection system?
    1. Chemicals can be applied for root control.
    2. Effectiveness of cleaning techniques can be studied under various conditions in collection system.
    3. Exact location and identification of problems can be determined.
    4. Service lines to homes can be inspected.
    5. TV camera can remove stoppages.

24. Jobs done by preventive maintenance crews include
    1. Assist emergency service crew to clear difficult stoppages on request.
    2. Change impellers on damaged pumps.
    3. Clear areas with root or grease problems on a regular basis.
    4. Clean segments of sewers where stoppages were removed by emergency crew.
    5. Clean sewers frequently enough to prevent problems from developing.

25. What are the advantages of a training facility constructed above-ground with clear 6-inch plastic pipe?
    1. Operators learn how to keep good records.
    2. Operators learn how to use sewer gas detection equipment.
    3. Operators learn proper procedures for use of sewer line cleaning equipment.
    4. Operators observe cleaning equipment in action and evaluate its effectiveness and usefulness.
    5. Operators see how material in a sewer is actually moved and removed by using different techniques of operating sewer cleaning equipment.

REVIEW QUESTIONS

26. Hazards that a wastewater collection system operator could encounter on the job include
    1. Drowning.
    2. Electrical shock.
    3. Excavation cave-ins.
    4. Explosive conditions.
    5. Poisonous or toxic gases.

27. Wastewater collection system operators can be protected from hazardous atmospheres in confined spaces by
    1. Calibrating atmospheric testing equipment before testing the atmosphere.
    2. Continuously testing entire work area for hazardous atmospheres when working in confined spaces.
    3. Testing for hazardous atmospheres before entering confined spaces.
    4. Ventilating confined spaces before entry and continuously while working in confined spaces.
    5. Wearing a self-contained breathing apparatus if necessary, but never in an explosive atmosphere.

End of Objective Test

FINAL EXAMINATION
AND
SUGGESTED ANSWERS
FOR
OPERATION AND MAINTENANCE OF
WASTEWATER COLLECTION SYSTEMS
VOLUME II

FINAL EXAMINATION
VOLUME II

This final examination was prepared **TO HELP YOU REVIEW** the material in this manual. The questions are divided into three types:

1. True-false,
2. Multiple choice, and
3. Short answer.

To work this examination:

1. Write the answer to each question in your notebook.
2. After you have worked a group of questions (you decide how many), check your answers with the suggested answers at the end of this exam, and
3. If you missed a question and don't understand why, reread the material in the manual.

You may wish to use this examination for review purposes when preparing for civil service and certification examinations.

Since you have already completed this course, you do not have to send your answers to California State University, Sacramento.

True-False

1. Reliability is the most important requirement for a lift station.
   1. True
   2. False
2. Submersible pumps are installed in dry wells.
   1. True
   2. False
3. Every lift station should be equipped with at least two pumps so they can both operate at the same time.
   1. True
   2. False
4. Pump isolation valves should be gate valves.
   1. True
   2. False
5. Effective equipment and sewer maintenance is the key to successful system performance.
   1. True
   2. False
6. When machinery is not shut off, locked out, and tagged properly, a maintenance operator could be cleaning a pump, the pump could start, and the operator could loose a finger.
   1. True
   2. False
7. Most electrical equipment does not specify the allowable current in amps on the nameplate.
   1. True
   2. False
8. Closing an electrical circuit is like closing a valve on a water pipe.
   1. True
   2. False
9. Piston pumps are commonly used in high velocity cleaners.
   1. True
   2. False
10. A pump and driver may be coupled together by a belt.
    1. True
    2. False
11. Long pump suction lines should be used to reduce energy losses due to pipe friction.
    1. True
    2. False
12. Packing is used to keep air from being sucked into a pump.
    1. True
    2. False
13. There are no risks or hazards associated with a deteriorated sewer system.
    1. True
    2. False

14. Personal health depends on your personal cleanliness.
    1. True
    2. False

15. Tetanus is difficult to prevent, but easy to treat.
    1. True
    2. False

16. Ammonia is a harmless gas.
    1. True
    2. False

17. Experts from the gas company may be called upon in an emergency to work in or near explosive mixtures.
    1. True
    2. False

18. Oxygen levels in sewers over 21.9 percent are never encountered by collection system operators.
    1. True
    2. False

19. Manhole atmospheres should be tested from top to bottom.
    1. True
    2. False

20. Gas test equipment should indicate the level of an atmospheric hazard on a dial or gage so the operator in a manhole can decide when conditions are hazardous.
    1. True
    2. False

21. A detailed record of what is underground is critical for the successful operation and maintenance of a wastewater collection system.
    1. True
    2. False

22. Unusual soil conditions discovered during construction should be recorded on "as-built" plans.
    1. True
    2. False

23. Accurate records can provide the necessary justification for additional staff.
    1. True
    2. False

24. Most collection systems are designed to be cleaned by preventive maintenance crews.
    1. True
    2. False

25. Maintenance that is scheduled too frequently is considered efficient.
    1. True
    2. False

26. Every effort should be made to prevent emergencies from occurring in collection systems.
    1. True
    2. False

27. Organization charts show the layout of sewers in a community.
    1. True
    2. False

28. The first priority of a wastewater collection system agency should be to complete scheduled preventive maintenance every day.
    1. True
    2. False

29. The flooding of a home caused by a stoppage is a very delicate public relations problem.
    1. True
    2. False

30. Closed-circuit television can be used to evaluate the condition of a wastewater collection system.
    1. True
    2. False

Multiple Choice

1. Pumps should not be allowed to start and stop frequently in lift stations because frequent motor starts
    1. Cause excessive wear on control circuit relays.
    2. Cause excessive wear on motors.
    3. Cause overheating.
    4. Consume more energy than a motor that operates continuously.
    5. Keep solids suspended in a wet well.

2. Limitations of float control systems include
    1. Float attachment line can break and call for all or none of the pumps to operate.
    2. Floats develop leaks.
    3. Grease and debris can enter the stilling well and hinder or stop the movement of the float.
    4. Sensitivity to fluctuations of water surface elevation in wet well.
    5. Signals activated by floats are easily transmitted to pumps.

3. Which of the following items should be inspected on new pumps?
    1. Cavitation
    2. Direction of rotation
    3. Drive mechanism
    4. Guards on rotating parts
    5. Packing gland or mechanical seal

4. What items should be inspected when responding to a station alarm at night?
    1. Dry well
    2. Interior lighting
    3. Motor control center and power panel
    4. Operation of ventilation equipment
    5. Wet well

5. Which of the following items are parts of an electric motor?
    1. Impeller
    2. Rotor
    3. Stator
    4. Volute
    5. Windings

6. Wearing rings are installed in a pump to
   1. Hold the shaft in position.
   2. Keep the impeller in place.
   3. Plug internal water leakage.
   4. Wear instead of impeller.
   5. Wear out the sleeves.
7. Before inspecting a pump impeller you should
   1. Close suction and discharge valves.
   2. Drain pump with bolts still in handhole cover until water flow stops.
   3. Open handhole covers and visually inspect for foreign objects which may injure you.
   4. Tag control panel.
   5. Turn off and lock out all electrical power.
8. Techniques available to a utility for assessing the condition of a collection system include
   1. Chemical grouting.
   2. Closed-circuit television.
   3. Insituform.
   4. Sewer line flow tests.
   5. Slip lining.
9. The major stumbling blocks to the implementation of a sewer rehabilitation program include identification of
   1. Consulting engineers to perform design work.
   2. Contractors to do the job.
   3. Funding to accomplish work.
   4. Regulatory agency to approve project.
   5. Staffing to handle program.
10. Which of the following precautions must be exercised when handling or storing lubricants?
    1. Do not create a fire hazard
    2. Discard lubricants that become contaminated by water or dirt
    3. Keep lids tight on containers
    4. Post "NO SMOKING" signs on the outside of buildings where lubricants are stored
    5. Wipe up spills
11. Measurement of the gases present in a manhole BEFORE the lid is removed is important to determine the
    1. Degree of hazard.
    2. Nature of any hazard.
    3. Need for ventilation.
    4. Number of operators needed topside.
    5. Possibility of leaks or dumps.
12. What is the MAIN REASON for the poor accident record of collection system operators in the past?
    1. Ignorance
    2. Lack of initiative
    3. Lack of interest
    4. Lack of training
    5. Negligence
13. Trench cave-ins can be caused by
    1. Changing conditions.
    2. Earthquakes.
    3. Improper shoring.
    4. Placing spoil away from edge of trench.
    5. Stable soil.
14. Safety programs are effective when
    1. Adequate safety equipment is available.
    2. Basic safety concepts and practices are thoroughly understood by all.
    3. Everyone participates and accepts their personal responsibilities for safety.
    4. Everyone realizes that safety is a continuing learning and re-learning process.
    5. Everyone realizes they should stop anyone performing an unsafe act and explain safe procedures.
15. Maps are needed to
    1. Cover office walls.
    2. Make parachutes to pull tag lines down sewers.
    3. Plan activities for crews.
    4. Prepare maintenance programs.
    5. Show locations of facilities.
16. Factors essential for planning a maintenance schedule include
    1. Desired effectiveness of schedule.
    2. Knowledge of collection system.
    3. Knowledge of maintenance procedures and equipment.
    4. Objective of activity.
    5. Timing of activity.
17. Public relations are important because we
    1. Like our jobs.
    2. Must deal with the public.
    3. Need lots of training.
    4. Want to finish our work in a hurry.
    5. Work for the public.
18. Some CRITICAL FACTORS that should be considered when developing the structure of a wastewater collection system agency include
    1. Existing and potential problems.
    2. How to keep the power rodder operating every day.
    3. Need for an above-ground clear plastic pipe training facility.
    4. Responsibility of agency.
    5. Size of wastewater collection system.
19. A sewer-use ordinance should specify who does the
    1. Enforcement.
    2. Monitoring.
    3. Regular cleaning of the main lines.
    4. Regular repairing of broken pipes.
    5. Regular sealing of leaky joints.
20. What are the advantages of a training facility constructed of clear 6-inch plastic pipe above ground?
    1. Learn how to keep good records
    2. Learn how to use sewer gas detection equipment
    3. Learn proper procedures for use of sewer line cleaning equipment
    4. Observe cleaning equipment in action and evaluate its effectiveness and usefulness
    5. See how material in a sewer is actually moved and removed by using different techniques of operating sewer cleaning equipment

Short Answer

1. Define the following terms:

   a. Cavitation,
   b. Discharge head, and
   c. Suction head.

2. Who should inspect a lift station after it is completed, but before it is accepted?
3. Why should you record all pertinent data when test operating a lift station?
4. How can nearby streams and rivers be protected from wastewater when a lift station fails?
5. What factors should be considered when determining the frequency of lift station visits?
6. Why should an emergency crew at a lift station notify the dispatcher when they will call in again?
7. What precautions should be taken before attempting to change fuses?
8. How can motors be kept trouble free?
9. How often should impellers be inspected for wear?
10. How can pump shafts be protected from damage?
11. Why should a pump with a mechanical seal never be allowed to run dry?
12. How can you determine if motor and pump sheaves are properly aligned?
13. Why does EPA emphasize the rehabilitation of sewers?
14. The public is aware of what kinds of problems created in sewer systems by extraneous flows?
15. Why is safe performance an important consideration for promotion?
16. Why do gases found in sewers tend to be found in low level or underground structures (confined spaces)?
17. What are possible ignition sources for an explosive atmosphere?
18. What causes excavation or trench sidewall cave-ins?
19. Why should maps be updated?
20. How would you prepare an effective schedule for maintaining a wastewater collection system?
21. How can maps help determine manpower requirements?
22. Why should collection system crew members be properly trained?
23. How can a collection system operator make positive personal contacts?
24. Why is a good outline of a report essential?
25. Could an existing preventive maintenance program over-perform?
26. List the priority responses to requests for emergency services.
27. What should be done when a private home becomes flooded with wastewater?
28. What are the advantages of video taping what is observed by the TV camera?
29. Why should a priority list be developed for scheduling work by preventive maintenance crews?

SUGGESTED ANSWERS FOR FINAL EXAMINATION

True-False

1. True Reliability is the most important requirement for a lift station.
2. False Submersible pumps are installed in wet wells.
3. False Lift stations should have two pumps so one will be available at all times.
4. True Pump isolation valves should be gate valves.
5. True Successful system performance depends on effective equipment and sewer maintenance.
6. True YOU could lose a finger if you were cleaning a pump that was not properly shut off, locked out and tagged properly, and the pump started accidentally.
7. False Most electrical equipment DOES contain the allowable current in amps on the nameplate.
8. False Closing an electrical circuit is like OPENING a valve on a water pipe.
9. True High velocity cleaners commonly use piston pumps.
10. True A pump and driver may be coupled together by a belt.
11. False SHORT pump suction lines should be used to reduce energy losses due to pipe friction.
12. True Packing is used to keep air from being sucked into a pump.
13. False There are many risks or hazards associated with a deteriorated sewer system such as exfiltration contaminating groundwater drinking supplies, inflow/infiltration overloading a treatment plant and streets falling into sewers.
14. True Personal health depends on your personal cleanliness.
15. False Tetanus is easy to prevent, but difficult to treat.
16. False Ammonia is a toxic gas.
17. True Experts from the gas company may be called upon in an emergency to work in or near explosive mixtures.

18. False Oxygen levels over 21.9 percent oxygen may be encountered in sewers by collection system operators if pure oxygen is being used to control hydrogen sulfide.

19. True Manhole atmospheres should be tested from top to bottom.

20. False Gas test equipment should have visual and audible alarms that are activated when a hazardous condition occurs to avoid the operator having to decide if a condition is hazardous.

21. True A detailed record of what is underground is critical for the successful operation and maintenance of a wastewater collection system.

22. True Record any unusual soil conditions discovered during construction on "as-built" plans.

23. True Accurate records can provide the necessary justification for additional staff.

24. False Most collection systems are designed to be self-cleaning.

25. False Maintenance that is scheduled too frequently is considered inefficient.

26. True Every effort should be made to prevent emergencies from occurring in collection systems.

27. False Organization charts show the structure and chain of command of an agency.

28. False The first priority of a wastewater collection system agency should be to have the ability to handle emergency service requests quickly and efficiently.

29. True The flooding of a home caused by a stoppage is a very delicate public relations problem.

30. True Closed-circuit television can be used to evaluate the condition of a wastewater collection system.

Multiple Choice

1. 1,2,3,4 Pumps should not be allowed to start and stop frequently in lift stations because frequent motor starts (1) cause excessive wear on control circuit relays, (2) cause excessive wear on motors, (3) cause overheating, and (4) consume more energy than a motor that operates continuously.

2. 1,2,3 Limitations of float control systems include float attachment line can break, floats can develop leaks, and grease and debris can enter the stilling well and hinder or stop the movement of the float.

3. 2,3,4,5 Items that should be inspected on new pumps include direction of rotation, drive mechanism, guards on rotating parts and packing gland or mechanical seal.

4. 1,2,3,4,5 Items that should be inspected when responding to a station alarm at night include the dry well, interior lighting, motor control center and power panel, operation of ventilation equipment and wet well.

5. 2,3,5 Parts of electric motors include rotors, stators and windings.

6. 3,4 Wearing rings are installed in a pump to plug internal water leakage and wear instead of impeller.

7. 1,2,3,4,5 Before inspecting an impeller you should turn off and lock out all electrical power to pump, tag control panel, close suction and discharge valves, drain pump with bolts still in handhole covers until water flow stops, and open handhole covers and visually inspect for foreign objects which may injure you.

8. 2,4 Techniques available to a utility for **ASSESSING** the condition of a collection system include closed-circuit television inspection and sewer line flow tests. Chemical grouting, Insituform and slip lining are rehabilitation methods.

9. 3,5 The major stumbling blocks to the implementation of a sewer rehabilitation program include identification of funding to accomplish work and staffing to handle program.

10. 1,2,3,4,5 Precautions that must be exercised when handling or storing lubricants include: do not create a fire hazard, discard lubricants that become contaminated with water or dirt, keep lids tight on containers, post "NO SMOKING" signs on the outside of buildings where lubricants are stored, and wipe up spills.

11. 1,2,5 Measurement of the gases present in a manhole BEFORE the lid is removed is important to determine the degree and nature of the hazard and also the possibility of leaks or dumps. Always ventilate a manhole and have at least two operators topside whenever anyone is in a manhole.

12. 5 Negligence is the main reason for the poor accident record of collection system operators in the past.

13. 1,2,3 Trench cave-ins can be caused by changing conditions, earthquakes, and improper shoring. Stable soil and placing spoil AWAY from edge of trench will help reduce the possibility of cave-ins.

14. 1,2,3,4,5 Safety programs are effective when adequate safety equipment is available, basic safety concepts and practices are thoroughly understood by all, everyone participates and accepts their personal responsibilities for safety, everyone realizes that safety is a continuing learning and relearning process, and everyone realizes they should stop anyone performing an unsafe act and explain safe procedures.

15. 3,4,5 Maps are needed to plan activities for crews, prepare maintenance programs, and show locations of facilities.

16. 1,2,3,4,5 Factors essential for planning a maintenance schedule include desired effectiveness of schedule, knowledge of collection system, knowledge of maintenance procedures and equipment, objective of activity, and timing of activity.

17. 2,5 Public relations are important because we must deal with the public and we work for the public.

18. 1,4,5 Some CRITICAL FACTORS that should be considered when developing the structure of a wastewater collection system agency include existing and potential problems, responsibility of agency, and size of collection system.

19. 1,2 A sewer-use ordinance should specify who does the enforcement and monitoring.

20. 3,4,5 Advantages of a training facility constructed of clear 6-inch plastic pipe above ground include learning proper procedures for use of sewer line cleaning equipment, observing cleaning equipment in action and evaluating its effectiveness and usefulness, and seeing how material in a sewer is actually moved and removed by using different techniques of operating sewer cleaning equipment.

Short Answer

1. Define the following terms.
   a. *CAVITATION.* The formation and collapse of a gas pocket or bubble on the blade of an impeller. The collapse of this gas pocket or bubble drives water into the impeller with a terrific force that can cause pitting on the impeller surface.
   b. *DISCHARGE HEAD.* The pressure (in feet or psi) on the discharge side of a pump. The pressure can be measured from the center line of the pump to the hydraulic grade line of the water in the discharge pipe.
   c. *SUCTION HEAD.* The POSITIVE pressure (in feet or psi) on the suction side of a pump. The pressure can be measured from the center line of the pump UP TO the elevation of the hydraulic grade line on the suction side of the pump.

2. After a lift station is completed but before it is accepted, it should be inspected by the engineer, the contractor, and the operators responsible for its operation and maintenance.

3. All pertinent data must be recorded when test operating a lift station so you have a record of conditions when the station started.

4. Nearby streams and rivers can be protected from wastewater when a lift station fails by the use of portable emergency equipment to pump wastewater to a functioning section of the downstream collection system.

5. The frequency of lift station visits depends on the following:
   1. Number of stations in community,
   2. Type of wastewater being conveyed,
   3. Potential damage from storms flooding station,
   4. Condition of equipment,
   5. Design of facility and equipment installed,
   6. Adequacy of preventive maintenance and overhaul program, and
   7. Attitude of operating agency towards operation and maintenance.

6. An emergency crew at a lift station should notify the dispatcher when they will call in again so in case a serious injury occurs and they are unable to contact the dispatcher, rescue operations can be started.

7. Before attempting to change fuses, turn off power and check both power lines for voltage. Use a fuse puller.

8. Motors can be kept trouble free with proper lubrication and maintenance.

9. Impellers should be inspected for wear on a regular basis such as every 6 months or annually, depending on pumping conditions. If grit, sand, or other abrasive material is being pumped, inspections should be more frequent.

10. Pump shafts can be protected from damage by the installation of shaft sleeves over the shaft in the area on the shaft where it passes through the stuffing box.

11. A pump with a mechanical seal (or any other type of seal) should never be run dry because water is required for seal lubrication.

12. Alignment of pump and motor sheave can be determined by (1) placing a straight-edge between the two pulleys or (2) pulling a string across both pulleys.

13. EPA emphasizes the rehabilitation of sewers to reduce the extraneous hydraulic loads on the sewer system and treatment facilities. These excessive loads increase treatment costs, result in the by-passing of untreated wastewater to the environment and can result in structural failure or weakened collection systems.

14. Problems caused by extraneous flows in sewer systems that the public is aware of include the back flooding into private property as a result of the surcharge or overloading of sewer mains and the degradation of the environment due to overflows from storm drains.

15. A reputation for a safe performance is an important professional characteristic. Concern for a safe performance will help you motivate, train and lead others and these are supervisor characteristics that gain promotion.

16. Gases found in sewers usually concentrate in low level or underground structures because many of the gases are heavier than air and are produced in the low levels in deposits and slimes.

17. Possible ignition sources for an explosive atmosphere include a spark from an automobile, an improper tool, a shoe nail, a cigarette, or an open flame.

18. Excavation or trench sidewall cave-ins can be caused by
    1. Failure to shore, possibly because of a deliberate shortcut to save time or expense,
    2. Inadequate shoring because of lack of knowledge or misjudgment of soil stability,
    3. Failure of shoring because of unsuspected bank loading caused by traffic or machinery vibration,
    4. Inadequate shoring maintenance or replacement after changes occur in the soils surrounding an excavation as a result of construction work or heavy rains,
    5. Failure of shoring material,
    6. Placement of spoil too near the trench edge, and
    7. Trench wall undercutting.

19. Maps must be updated to maintain their usefulness and to reduce time-consuming and costly mistakes.

20. To prepare an effective schedule for maintaining a wastewater collection system, a knowledge of the collection system, maintenance procedures, and available equipment and manpower are very important. Actual maintenance schedules must attempt to schedule jobs only when needed. Effectiveness of the maintenance program must be continuously evaluated and schedules adjusted as necessary.

21. Maps can help determine manpower requirements in the following ways:

    1. Accurate maps reduce wasted time in the field looking for items that should be on maps. If maps are inaccurate, try to obtain staff to update and improve accuracy of maps.
    2. Maps show locations of manholes and accessibility for operators and equipment.

22. Collection system crew members must be properly trained so they can effectively accomplish the tasks they are assigned. Effectiveness is indicated by the job being properly done quickly and safely.

23. Positive personal contacts can be made by having a neat appearance, such as wearing a uniform or clean work clothes. A courteous and sincere attitude towards other people is very helpful. A knowledge of how to solve the problem is impressive.

24. A good outline helps to organize the report and present information in a logical sequence that is easily understood.

25. Yes, an existing preventive maintenance program could over-perform and conduct activities more frequently than are needed to meet the agency's objectives.

26. Priority responses to requests for emergency services are as follows:

    1. Flooded home or business,
    2. Manhole overflowing,
    3. Manhole cover off,
    4. Cleanout overflowing, and
    5. Home service backed up.

27. When a private home becomes flooded with wastewater, try to remove the cause of flooding and assist the people living in the home to clean and remove articles which may have been damaged or will be damaged if left in place.

28. Advantages of video TV include:

    1. Showing condition of collection system to Director of Public Works, staff engineers and other crews,
    2. Locating and identifying problems,
    3. Confirming or changing evaluation techniques to identify causes of stoppages,
    4. Permitting supervisors to see and evaluate effectiveness of power cleaning equipment, and
    5. Evaluating effectiveness of TV unit.

29. A priority list should be developed for scheduling work by preventive maintenance crews to provide an organized approach to solving problems and insuring the completion of necessary jobs.

COLLECTION SYSTEM WORDS

by

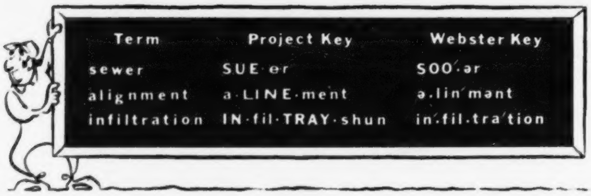
George Freeland

OPERATOR'S PROJECT PRONUNCIATION KEY

by Warren L. Prentice

The Operator's Project Pronunciation Key is designed to aid you in the pronunciation of new words. While this Key is based primarily on familiar sounds, it does not attempt to follow any particular pronunciation guide. This Key is designed solely to aid operators in this program.

You may find it helpful to refer to other available sources for pronunciation help. Each current standard dictionary contains a guide to its own pronunciation Key. Each Key will be different from each other and from this Key. Examples of the differences between the Key used in this program and the Webster's New World Dictionary Key, Second College Edition, 1972[1] are shown below:



Term	Project Key	Webster Key
sewer	SUE·er	SOO′·ər
alignment	a·LINE·ment	ə·lin′mənt
infiltration	IN·fil·TRAY·shun	in′·fil·tra′tion

In using this Key, you should accent (say louder) the syllable which appears in capital letters. The following chart is presented to give examples of how to pronounce words using the Operator's Project Key.

	Syllable			
	1st	2nd	3rd	4th
Word				
Sewer	SUE	er		
Alignment	a	LINE	ment	
Infiltration	IN	fil	TRAY	shun

The first word, sewer, has its first syllable accented. The second word, alignment, has its second syllable accented. The third word, infiltration, has its first and third syllables accented.

We hope you will find the Key useful in unlocking the pronunciation of any new word.

EXPLANATION OF WORDS

The meanings of words in the glossary of this manual are based on current usage by the wastewater collection profession and definitions given in *GLOSSARY — WATER AND WASTEWATER CONTROL ENGINEERING*, prepared by the Joint Editorial Board representing APHA, ASCE, AWWA and WPCF,* 1981. Certain words used by wastewater collection system operators tend to have slightly different meanings in some regions of the United States. We have tried to standardize word meanings as much as possible.

**APHA.* *American Public Health Association.*
ASCE. *American Society of Civil Engineers.*
AWWA. *American Water Works Association.*
WPCF. *Water Pollution Control Federation.*

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[1] *The Webster's New World Dictionary, Second College Edition, 1972 was chosen rather than an unabridged dictionary because of its availability to most collection system operators.*

GLOSSARY

A

ABANDONED (a-BAN-dund) ABANDONED

No longer in use; a length, section or portion of a collection system no longer in service and left in place, underground. For example, when a house or building is razed or removed the service connection may be left open and unused.

ABATEMENT (a-BAIT-ment) ABATEMENT

Putting an end to an undesirable or unlawful condition affecting the wastewater collection system. A property owner found to have inflow sources connected to the collection system may be issued a "NOTICE OF ABATEMENT." Such notices will usually describe the violation, suggest corrective measures and grant a period of time for compliance.

ABSORPTION (ab-SORP-shun) ABSORPTION

The taking in or soaking up of one substance into the body of another by molecular or chemical action (as tree roots absorb dissolved nutrients in the soil).

ABSORPTION CAPACITY ABSORPTION CAPACITY

The amount of liquid which a solid material can absorb. Sand, as an example, can hold approximately one third of its volume in water, or three cubic feet of dry sand can contain one cubic foot of water. A denser soil, such as clay, can hold much less water and thus has a lower absorption capacity.

ABSORPTION RATE ABSORPTION RATE

The speed at which a measured amount of solid material can absorb a measured amount of liquid. Under pressure, water can infiltrate a given volume of gravel very rapidly. The water will penetrate (or be absorbed by) sand more slowly and will take even longer to saturate the same amount of clay.

AEROBIC (AIR-O-bick) AEROBIC

A condition in which "free" or dissolved oxygen is present in the aquatic (water) environment.

AIR BLOWER AIR BLOWER

A device used to ventilate manholes and lift stations.

AIR GAP AIR GAP

An open vertical drop, or vertical empty space, between a drinking (potable) water supply and the point of use. This gap prevents back siphonage because there is no way wastewater can reach the drinking water. Air gap devices are used to provide adequate space above the top of a manhole and the end of the hose from the fire hydrant. This gap insures that no wastewater will flow out the top of a manhole, reach the end of the hose from a fire hydrant, and be sucked back up the hose to the water supply.

AIR TEST AIR TEST

A method of inspecting a sewer pipe for leaks. Inflatable or similar plugs are placed in the line and the space between these plugs is pressurized with air. A drop in pressure indicates the line or run being tested has leaks.

AIR TEST, QUICK AIR TEST, QUICK

(See QUICK AIR TEST)

ALIGNMENT (a-LINE-ment) ALIGNMENT

The proper positioning of parts in a system. The alignment of a pipeline or other line refers to its location and direction.

ALLUVIAL DEPOSIT (a-LOU-vee-al) ALLUIVIAL DEPOSIT

Sediment (clay, silt, sand, gravel) deposited in place by the action of running water.

ALTERNATING CURRENT (A.C.) ALTERNATING CURRENT (A.C.)

An electric current that reverses its direction (positive/negative values) at regular intervals.

AMBIENT AMBIENT

Surrounding. Ambient or surrounding atmosphere.

AMPERAGE (AM-purr-age) AMPERAGE

The strength of an electric current measured in amperes.

AMPERE (AM-peer) AMPERE

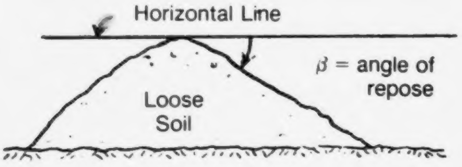
The unit used to measure current strength. The current produced by an electromotive force of one volt acting through a resistance of one ohm.

ANAEROBIC (AN-air-O-bick) ANAEROBIC

A condition in which "free" or dissolved oxygen is *NOT* present in the aquatic (water) environment.

ANGLE OF REPOSE ANGLE OF REPOSE

The angle between a horizontal line and the slope or surface of unsupported material such as gravel, sand, or loose soil. Also called the "natural slope."



ANIMAL WASTES ANIMAL WASTES

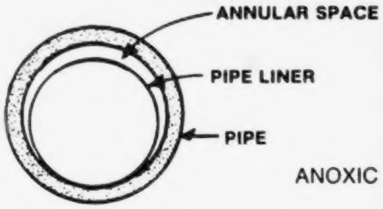
(1) Urine and fecal wastes of living animals.

(2) Wastes of animal tissue from meat processing (feathers included), hospital, surgical and clinical facility wastes of animal types.

(3) Similar to (2) above, but cooked or prepared wastes of animal tissues and bones from domestic or commercial food preparation.

ANNULAR SPACE (AN-ul-are) ANNULAR SPACE

A ring-shaped space. For example, the space between the outside of a pipe liner and the inside of a pipe.



ANOXIC ANOXIC

Oxygen deficient or lacking sufficient oxygen.

APARTMENT COMPLEX APARTMENT COMPLEX

One or more residential buildings at a single location. An apartment building may contain several residences with a single connection to the wastewater collection system. A complex can have several buildings with a single connection.

APPURTENANCE (a-PURR-ten-nans) APPURTENANCE

Machinery, appliances, structures and other parts of the main structure necessary to allow it to operate as intended, but not considered part of the main structure.

AQUIFER (ACK-wi-fer) AQUIFER

A porous, water-bearing geologic formation. Usually refers only to materials capable of yielding a substantial amount of water.

ARCH ARCH

The curved top of a sewer pipe or conduit.

ARTIFICIAL GROUNDWATER TABLE ARTIFICIAL GROUNDWATER TABLE

A groundwater table that is changed by artificial means. Examples of activities that artificially raise the level of a groundwater table include agricultural irrigation, dams and excessive sewer line exfiltration. A groundwater table can be artificially lowered by sewer line infiltration, water wells, and similar drainage methods.

ASPHYXIATION (ass-FIX-ee-a-shun) ASPHYXIATION

An extreme condition often resulting in death due to a lack of oxygen and excess carbon dioxide in the blood from any cause. Also called suffocation.

AUGER (AW-grr) AUGER

A sharp tool used to go through and break up or remove various materials that become lodged in sewers.

B

BACKFILL BACKFILL

(1) Material used to fill in a trench or excavation.

(2) The act of filling a trench or excavation, usually after a pipe or some type of structure has been placed in the trench or excavation.

BACKFILL, BORROW BACKFILL, BORROW

(See BORROW)

BACKFILL COMPACTION BACKFILL COMPACTION

(1) Tamping, rolling or otherwise mechanically compressing material used as backfill for a trench or excavation. Backfill is compressed to increase its density so that it will support the weight of machinery or other loads after the material is in place in the excavation.

(2) Compaction of a backfill material can be expressed as a percentage of the maximum compactability, density or load capacity of the material being used.

BACKFILL, SELECT BACKFILL, SELECT

(See SELECT BACKFILL)

BACKFLUSHING BACKFLUSHING

A procedure used to wash settled waste matter off upstream structures to prevent odors from developing after a main line stoppage has been cleared.

BACKHOE BACKHOE

An excavating machine whose bucket is rigidly attached to a hinged stick on a boom and is drawn toward the machine during excavation.

BACKWATER GATE BACKWATER GATE

A gate installed at the end of a drain or outlet pipe to prevent the backward flow of water or wastewater. Generally used on storm sewer outlets into streams to prevent backward flow during times of flood or high tide. Also called a TIDE GATE.

BACTERIA (back-TEAR-e-ah) BACTERIA

Bacteria are living organisms, microscopic in size, which consist of a single cell. Most bacteria use organic matter for their food and produce waste products as a result of their life processes.

BALLING BALLING

A method of hydraulically cleaning a sewer or storm drain by using the pressure of a water head to create a high cleansing velocity of water around the ball. In normal operation, the ball is restrained by a cable while water washes past the ball at high velocity. Special sewer cleaning balls have an outside tread that causes them to spin or rotate, resulting in a "scrubbing" action of the flowing water along the pipe wall.

BAR RACK BAR RACK

A screen composed of parallel bars, either vertical or inclined, placed in a sewer or other waterway to catch debris. The screenings may be raked from it.

BARREL BARREL

(1) The cylindrical part of a pipe that may have a bell on one end.

(2) The cylindrical part of a manhole between the cone at the top and the shelf at the bottom.

BEDDING BEDDING

The prepared base or bottom of a trench or excavation on which a pipe or other underground structure is supported.

BEDDING COMPACTION BEDDING COMPACTION

(1) Tamping, rolling or otherwise mechanically compressing material used as bedding for a pipe or other underground structure to a density that will support expected loads.

(2) Bedding compaction can be expressed as a percentage of the maximum load capacity of the bedding material.

(3) Bedding compaction also can be expressed in load capacity of pounds per square foot.

BEDDING DESTRUCTION BEDDING DESTRUCTION

Loss of grade, load capacity or material of a bedding.

BEDDING DISPLACEMENT BEDDING DISPLACEMENT

Bedding which has been removed after placement and compaction. In a sewer pipe system, this can take place as a result of washouts due to infiltration, earth shifts or slides, damage from nearby excavations and/or improper backfill methods.

BEDDING FAULTS BEDDING FAULTS

Locations where bedding was improperly applied and thus failed.

BEDDING GRADE BEDDING GRADE

(1) In a gravity-flow sewer system, pipe bedding is constructed and compacted to the design grade of the pipe. This is usually expressed in a percentage. A 0.5 percent grade would be a drop of one-half foot per hundred feet of pipe.

(2) Bedding grade for a gravity-flow sewer pipe can also be specified as elevation above mean sea level at specific points.

BEDDING, MANHOLE BEDDING, MAHOLE

(See MANHOLE BEDDING)

BEDDING MATERIAL, SELECT BEDDING MATERIAL, SELECT

(See SELECT BEDDING)

BELL BELL

(1) In pipe fitting, the enlarged female end of a pipe into which the male end fits. Also called a HUB.
(2) In plumbing, the expanded female end of a wiped joint.

BELL-AND-SPIGOT JOINT BELL-AND-SPIGOT JOINT

A form of joint used on pipes which have an enlarged diameter or bell at one end, and a spigot at the other which fits into and is laid in the bell. The joint is then made tight by lead, cement, rubber "O" ring, or other jointing compounds or materials.

BELLMOUTH BELLMOUTH

An expanding, rounded entrance to a pipe or orifice.

BEND BEND

A piece of pipe bent or cast into an angular shape.

BIOCHEMICAL OXYGEN DEMAND (BOD) BIOCHEMICAL OXYGEN DEMAND (BOD)

The rate at which microorganisms use the oxygen in water or wastewater while stabilizing decomposable organic matter under aerobic conditions. In decomposition, organic matter serves as food for the bacteria and energy results from its oxidation.

BIT BIT

(1) Cutting blade used in rodding (pipe clearing) operations.

(2) Cutting teeth on the auger head of a sewer boring tool.

BLOCKAGE BLOCKAGE

(1) Partial or complete interruption of flow as a result of some obstruction in a sewer.

(2) When a collection system becomes plugged and the flow backs up, it is said to have a "blockage."

Commonly called a STOPPAGE.

BLOWER BLOWER

A device used to ventilate manholes and lift stations.

BLUEPRINT BLUEPRINT

A photographic print in white on a bright blue background used for copying maps, mechanical drawings, construction plans and architects' plans.

BOD (BEE-OH-DEE) BOD

Biochemical Oxygen Demand. The rate at which microorganisms use the oxygen in water or wastewater while stabilizing decomposable organic matter under aerobic conditions. In decomposition, organic matter serves as food for the bacteria and energy results from its oxidation.

BORROW BACKFILL BORROW BACKFILL

Material used for backfilling a trench or excavation which was not the original material removed during excavation. This is a common practice where tests on the original material show it to have poor compactability or load capacity. Also called IMPORTED BACKFILL.

BRACES BRACES

(See CROSS BRACES)

BRANCH MANHOLE BRANCH MANHOLE

A sewer or drain manhole which has more than one pipe feeding into it. A standard manhole will have one outlet and one inlet. A branch manhole will have one outlet and two or more inlets.

BRANCH SEWER BRANCH SEWER

A sewer that receives wastewater from a relatively small area and discharges into a main sewer serving more than one branch-sewer area.

BREAK BREAK

A fracture or opening in a pipe, manhole or other structure due to structural failure and/or structural defect.

BRICKWORK BRICKWORK

A structure made of brick, such as in older sewers.

BRINELLING BRINELLING

This type of bearing failure appears as tiny indentations (dents) high on the shoulder of the race.

BROKEN HUB BROKEN HUB

In bell-and-spigot pipe, the bell portion is frequently called the "hub." A fracture or break in the bell portion is called a "broken hub."

BROKEN SECTION BROKEN SECTION

A run of pipe between two joints is referred to as a "section." A fracture in a section is called a "broken section."

BUCKET BUCKET

(1) A special device designed to be pulled along a sewer for the removal of debris from the sewer. The bucket has one end open with the opposite end having a set of jaws. When pulled from the jaw end, the jaws are automatically opened. When pulled from the other end, the jaws close. In operation, the bucket is pulled into the debris from the jaw end and to a point where some of the debris has been forced into the bucket. The bucket is then pulled out of the sewer from the other end, causing the jaws to close and retain the debris. Once removed from the manhole, the bucket is emptied and the process repeated.

(2) A conventional bail is used in BUCKETING OUT.

BUCKET BAIL BUCKET BAIL

The pulling handle on a bucket machine.

BUCKET MACHINE BUCKET MACHINE

A powered winch machine designed for operation over a manhole. The machine controls the travel of buckets used to clean sewers.

BUCKETING OUT BUCKETING OUT

An expression used to describe removal of debris from a manhole with a pail on a rope. In balling or high-velocity cleaning of sewers, debris is washed into the downstream manhole. Removal of this debris by scooping it into pails and hauling debris out is termed "bucketing out."

BUILDING SERVICE BUILDING SERVICE

A saddle or "Y" connection to a lateral or branch sewer for connection of a building lateral.

BUILDING SEWER BUILDING SEWER

A gravity-flow pipeline connecting a building wastewater collection system to a lateral or branch sewer. The building sewer may begin at the outside of the building's foundation wall or some distance (such as 2 to 10 feet) from the wall, depending on local sewer ordinances. Also called a HOUSE CONNECTION or a SERVICE CONNECTION.

BUILDING WASTEWATER COLLECTION SYSTEM BUILDING WASTEWATER COLLECTION SYSTEM

All of the wastewater drain pipes and their hardware that connect plumbing fixtures inside or adjacent to a building to the building sewers. This includes traps, vents and clean-outs.

BY-PASS BY-PASS

A pipe, valve, gate, weir, trench or other device designed to permit all or part of a wastewater flow to be diverted from usual channels or flow. Sometimes refers to a special line which carries the flow around a facility or device that needs maintenance or repair.

BY-PASSING BY-PASSING

The act of causing all or part of a flow to be diverted from its usual channels. In a wastewater treatment plant, overload flows should be by-passed into a holding pond for future treatment.

C

C-ZONED C-ZONED

An area set aside for commercial use.

CABLE STRAIN RELIEF CABLE STRAIN RELIEF

A mesh type of device that grips the cable to prevent any strain on the power cable from reaching the connections to the camera and the light.

CAPILLARY EFFECT (CAP-i-larry) CAPILLARY EFFECT

Also called "wicking effect." The ability of a liquid to rise above an established level to saturate a porous solid.

CATCH BASIN CATCH BASIN

A chamber or well used with storm or combined sewers as a means of removing grit which might otherwise enter and be deposited in sewers. Also see STORM WATER INLET and CURB INLET.

CAULK (KAWK) CAULK

To stop up and make watertight the joints of a pipe by filling the joints with a waterproof compound or material.

CAULKING (KAWK-ing) CAULKING

(1) A waterproof compound or material used to fill a pipe joint.

(2) The act of using a waterproof compound or material to fill a pipe joint.

CAUTION CAUTION

This word indicates that equipment might be damaged if care is not taken.

CAVITATION (CAV-i-TAY-shun) CAVITATION

The formation and collapse of a gas pocket or bubble on the blade of an impeller. The collapse of this gas pocket or bubble drives water into the impeller with a terrific force that can cause pitting on the impeller surface.

CENTRIFUGAL PUMP CENTRIFUGAL PUMP

A pump consisting of an impeller fixed on a rotating shaft and enclosed in a casing, and having an inlet and a discharge connection. As the rotating impeller whirls the liquid around, centrifugal force builds up enough pressure to force the liquid through the discharge outlet.

CESSPOOL CESSPOOL

A lined or partially lined excavation or pit for dumping raw household wastewater for natural decomposition and percolation into the soil.

CFS CFS

Initials stand for "Cubic Feet per Second," a measure of flow rate.

CHECK VALVE CHECK VALVE

A special valve with a hinged disc or flap that opens in the direction of normal flow and is forced shut when flows attempt to go in the reverse or opposite direction of normal flows.

CHEMICAL GROUT CHEMICAL GROUT

Two chemical solutions that form a solid when combined. Solidification time is controlled by the strength of the mixtures used and the temperature.

CHEMICAL GROUTING CHEMICAL GROUTING

Sealing leaks in a pipeline or manhole structure by injecting a chemical grout. In pipelines, the chemicals are injected through a device called a "packer." In operation, the packer is located at the leak point with the use of a television camera. Inflatable boots at either end of the packer isolate the leak point and the grouting chemicals are then forced into the leak under pressure. After allowing time for the grout to set, the packer is deflated and moved to the next location.

CIRCUIT CIRCUIT

The complete path of an electric current, including the generating apparatus or other source; or, a specific segment or section of the complete path.

CIRCUIT BREAKER CIRCUIT BREAKER

A safety device in an electrical circuit that automatically shuts off the circuit when it becomes overloaded. The device can be manually reset.

CHLORINATOR CHLORINATOR

A device used to regulate the transfer of chlorine from a container to flowing wastewater for such purposes as odor control and disinfection.

CLEANING, PIPE CLEANING, PIPE

(See PIPE CLEANING)

CLEANOUT CLEANOUT

An opening (usually covered or capped) in a wastewater collection system used for inserting tools, rods or snakes while cleaning a pipeline or clearing a stoppage.

CLEANOUT, TWO-WAY CLEANOUT, TWO-WAY

A cleanout designed for rodding or working a snake into a pipe in either direction. Two-way cleanouts are often used in building lateral pipes at or near a property line.

CLINICAL LABORATORY CLINICAL LABORATORY

A special medical facility devoted to the identification of diseases and ailments through tests, studies and culture growths. Services of a clinical laboratory might be necessary in the event of an accidental or intentional release or contagious and/or infectious wastes into a collection system.

COAGULATE (co-AGG-you-late) COAGULATE

The use of chemicals that cause very fine particles to clump together into larger particles. This makes it easier to separate the solids from the liquids by settling, skimming, draining or filtering.

COHESIVE (coe-HE-sive) COHESIVE

Tending to stick together.

COLLAPSED PIPE COLLAPSED PIPE

A pipe that has one or more points in its length which have been crushed or partially crushed by exterior pressures or impacts.

COLLECTION MAIN COLLECTION MAIN

A collection pipe to which building laterals are connected.

COLLECTION SYSTEM COLLECTION SYSTEM

A network of pipes, manholes, cleanouts, traps, siphons, lift stations and other structures used to collect all wastewater and wastewater-carried wastes of an area and transport them to a treatment plant or disposal system. The collection system includes land, wastewater lines and appurtenances, pumping stations and general property.

COLLOIDS (KOL-loids) COLLOIDS

Very small, finely divided solids (particles that do not dissolve) that remain dispersed in a liquid for a long time due to their small size and electrical charge.

COMBINED SEWER COMBINED SEWER

A sewer intended to receive both wastewater and storm or surface water.

COMBINED SYSTEM COMBINED SYSTEM

A sewer designed to carry both sanitary wastewaters and storm or surface water runoff.

COMBINED WASTEWATER COMBINED WASTEWATER

A mixture of surface runoff and other wastewater such as domestic of industrial wastewater.

COMMERCIAL CONTRIBUTION COMMERCIAL CONTRIBUTION

Liquid and liquid-carried wastes dumped by commercial establishments into the wastewater collection system. Used in this context, commercial contributions are distinct from domestic and industrial sources of wastewater contributions. Examples of high-yield commercial sources are laundries, restaurants and hotels.

COMMERCIAL TELEVISION QUALITY COMMERCIAL TELEVISION QUALITY

Refers to picture quality about the level of a television picture. Commercial television pictures are considered to have resolutions between 350 and 525 lines. This is higher quality than surveillance quality and lower quality than inspection quality pictures.

COMMINUTOR (com-mih-NEW-ter) COMMINUTOR

A device used to reduce the size of solid chunks in wastewater by shredding (comminuting). The shredding action can be visualized if you imagine many scissors cutting to shreds all the large solids in the wastewater.

COMPACTED BACKFILL COMPACTED BACKFILL

(See BACKFILL COMPACTION)

COMPACTED BEDDING COMPACTED BEDDING

(See BEDDING COMPACTION)

COMPACTION COMPACTION

Tamping or rolling of a material to achieve a surface or density that is able to support predicted loads.

COMPACTION TEST COMPACTION TEST

Any method of determining the weight a compacted material is able to support without damage or displacement. Usually stated in pounds per square foot.

COMPUTED CONTRIBUTION COMPUTED CONTRIBUTION

A liquid or liquid-carried contribution to a collection system that is computed on the basis of expected discharges from all of the sources as opposed to actual measurement or metering. Also see ESTIMATED CONTRIBUTION.

COMPUTED COMMERCIAL CONTRIBUTION COMPUTED COMMERCIAL CONTRIBUTION

That part of a collection system flow computed to originate in the commercial establishments on the basis of expected flows from all commercial sources.

COMPUTED DOMESTIC CONTRIBUTION COMPUTED DOMESTIC CONTRIBUTION

That part of a collection system flow computed to originate in the residential facilities based on the average flow contribution from each person.

COMPUTED FACILITY CONTRIBUTION COMPUTED FACILITY CONTRIBUTION

The computed liquid-waste discharge from a single facility based on the sources of waste flows in the facility.

COMPUTED INDUSTRIAL CONTRIBUTION COMPUTED INDUSTRIAL CONTRIBUTION

The computed liquid-waste discharge from industrial operations based on the expected discharges from all sources.

COMPUTED PER CAPITA CONTRIBUTION COMPUTED PER CAPITA CONTRIBUTION

The computed wastewater contribution from a domestic area, based on the population of the area. In the United States, the daily average wastewater contribution is considered to be 100 gallons per capita per day (100 gpcd).

COMPUTED TOTAL CONTRIBUTION COMPUTED TOTAL CONTRIBUTION

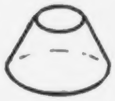
The total anticipated load on a wastewater treatment plant or the total anticipated flow in any collection system area based on the combined computed contributions of all connections to the system.

COMPUTED COLLECTION SYSTEM CONTRIBUTION COMPUTED COLLECTION SYSTEM CONTRIBUTION

That part of a collection system flow computed to be actual domestic and industrial wastewater. Applied to infiltration/inflow research, the computed domestic and industrial wastewater contribution is subtracted from a total flow to determine infiltration/inflow amounts.

CONCENTRIC MANHOLE CONE CONCENTRIC MANHOLE CONE

Cone tapers uniformly from barrel to manhole cover.



CONCRETE CRADLE CONCRETE CRADLE

A device made of concrete that is designed to support sewer pipe.

CONDUCTOR **CONDUCTOR**

(1) A pipe which carries a liquid load from one point to another point. In a wastewater collection system, a conductor is often a large pipe with no service connections. Also called a CONDUIT, MONITOR, INTERCEPTOR or INTERCONNECTOR.

(2) In plumbing, a line conducting water from the roof to the storm drain or other means of disposal. Also called a DOWNSPOUT.

(3) In electricity, a substance, body, device or wire that readily conducts or carries electrical current.

CONDUIT **CONDUIT**

Any artificial or natural duct, either open or closed, for conveying fluids from one point to another. An electrical conduit conveys electricity.

CONFINED SPACE* **CONFINED SPACE**

A space defined by the concurrent existence of the following conditions:

A. Existing ventilation is insufficient to remove dangerous air contamination and/or oxygen deficiency which may exist or develop, and

B. Ready access or egress (getting out) for the removal of a suddenly disabled employee (operator) is difficult due to the location and/or size of the opening(s).

Also see definitions of DANGEROUS AIR CONTAMINATION and OXYGEN DEFICIENCY.

CONTAMINATION **CONTAMINATION**

Introduction into water of any microorganisms, chemicals, wastes, or wastewater in a concentration that makes the water unfit for its intended use.

CONTRIBUTION **CONTRIBUTION**

Waters, wastewaters or liquid-carried wastes entering a wastewater collection system.

CORROSION **CORROSION**

The gradual decomposition or destruction of a material due to chemical action, often due to an electrochemical reaction. Corrosion starts at the surface of a material and moves inward, such as the chemical action upon manholes and sewer pipe materials.

COULOMB (COO-lahm) **COULOMB**

A measurement of the amount of electrical charge conveyed by an electric current of one ampere in one second. One coulomb equals about 6.25×10^{18} electrons (6,250,000,000,000,000,000 electrons).

COUPLING **COUPLING**

(1) A threaded sleeve used to connect two pipes.

(2) A device used to connect two adjacent parts, such as a pipe coupling, hose coupling or drive coupling.

CROSS BRACES **CROSS BRACES**

Shoring members placed across a trench to hold other horizontal and vertical members in place.

CROSS CONNECTION **CROSS CONNECTION**

(1) A connection between a storm drain system and a sanitary collection system.

(2) Less frequently used to mean a connection between two sections of a collection system to handle anticipated overloads of one system.

(3) A connection between drinking (potable) water and an unsafe water supply.

CURB INLET **CURB INLET**

A chamber or well built at the curbline of a street to admit gutter flow to the storm water drainage system. Also see STORM WATER INLET and CATCH BASIN.

CURRENT **CURRENT**

A movement or flow of electricity.

Water flowing in a pipe is measured in gallons per second past a certain point, not by the number of water molecules going past a point. Electric current is measured by the number of coulombs per second flowing past a certain point in a conductor. A coulomb is equal to about 6.25×10^{18} electrons (6,250,000,000,000,000,000 electrons). A flow of one coulomb per second is called 1 ampere, the unit of the rate of flow of current.

D

DANGEROUS AIR CONTAMINATION DANGEROUS AIR CONTAMINATION

An atmosphere presenting a threat of causing death, injury, acute illness, or disablement due to the presence of flammable and/or explosive, toxic or otherwise injurious or incapacitating substances.

A. Dangerous air contamination due to the flammability of a gas or vapor is defined as an atmosphere containing the gas or vapor at a concentration greater than 20 percent of its lower explosive (lower flammable) limit.

B. Dangerous air contamination due to a combustible particulate is defined as a concentration greater than 20 percent of the minimum explosive concentration of the particulate.

C. Dangerous air contamination due to the toxicity of a substance is defined as the atmospheric concentration immediately hazardous to life or health.

DATA-VIEW DATA-VIEW

A high-speed reporting and recording system used with closed circuit pipeline television equipment. Data-view provides digital indexing of date, job number, footages and air test pressures in the television picture itself. Where video tape recordings of television pipe inspections or pipe sealing activities are made, data-view reports are automatically recorded on the taped pictures.

DEADEND MANHOLE DEADEND MANHOLE

A manhole located at the upstream end of a sewer and having no inlet pipe. Also called a TERMINAL MANHOLE.

DEBRIS (de-BREE) DEBRIS

Any material in wastewater found floating, suspended or moving along the bottom of a sewer. This material may cause stoppages by getting hung up on roots or settling out in a sewer. Debris includes grit, paper, plastic, rubber, silt, and all materials except liquids.

DEBRIS, INFILTRATED DEBRIS, INFILTRATED

(See INFILTRATED DEBRIS)

DECOMPOSED PIPE DECOMPOSED PIPE

Pipe which has been destroyed or portions of pipe weakened by chemical actions.

DECOMPOSITION, DECAY DECOMPOSITION, DECAY

Processes that convert unstable materials into more stable forms by chemical or biological action. Waste treatment encourages decay in a controlled situation so that material may be disposed of in a stable form. When organic matter decays under anaerobic conditions (putrefaction), undesirable odors are produced. The aerobic processes in common use for wastewater treatment produce much less objectionable odors.

DEFECT DEFECT

A point where a pipe or system structure has been damaged or has a fault.

DEFECT, SURFACED DEFECT, SURFACED

(see SURFACED DEFECT)

DEFLECTED DEFLECTED

(1) Pipe which has been forced out of round by external pressures. This happens mainly to fiber and plastic pipes where backfill compaction has resulted in unequal pressures on all sides of the pipe.

(2) Pipe whose direction has been changed either to the left, right, up, or down.

DEGRADATION (de-grah-DAY-shun) DEGRADATION

The conversion or breakdown of a substance to simpler compounds. For example, the degradation of organic matter to carbon dioxide and water.

DESTROYED PIPE DESTROYED PIPE

Pipe which has been damaged, decomposed, deflected, crushed or collapsed to a point that it must be replaced.

DETENTION DETENTION

The delay or holding of the flow of water and water-carried wastes in a pipe system. This can be caused by a restriction in the pipe, a stoppage or a dip. Detention also means the time water is held or stored in a basin or a wet well. Sometimes called RETENTION.

CONFINED SPACES, General Industry Safety Orders, Article 108, Title 8, California Administrative Code, Cal/OSHA Consultation Service, Sacramento, California, October 1980.

DETRITUS (de-TRY-tus) DETRITUS

The heavy, coarse mixture of grit and organic material carried by wastewater. Also called GRIT.

DEWATER DEWATER

To drain or remove water from an enclosure. A structure may be dewatered so that it can be inspected or repaired. Dewater also means draining or removing water from sludge to increase the solids concentration.

DIP DIP

A point in a sewer pipe where a drain grade defect results in a puddle of standing water when there is no flow. If the grade defect is severe enough to cause the standing water to fill the pipe at any point (preventing passage of air through the pipe), it is called a "trap dip," "full dip" or "filled dip."

DIRECT CURRENT (D.C.) DIRECT CURRENT (D.C.)

Electrical current flowing in one direction only and essentially free from pulsation.

DISCHARGE HEAD DISCHARGE HEAD

The pressure (in feet or pounds per square inch (psi)) on the discharge side of a pump. The pressure can be measured from the center line of the pump to the hydraulic grade line of the water in the discharge pipe.

DISINFECTION (DIS-in-feck-shun) DISINFECTION

The process designed to kill most microorganisms in wastewater, including essentially all pathogenic (disease-causing) bacteria. There are several ways to disinfect, with chlorine being the most frequently used in water and wastewater treatment plants.

DISPLACED PIPE DISPLACED PIPE

A run or section of sewer pipe that has been pushed out of alignment by external forces.

DISTURBED SOIL DISTURBED SOIL

Soil which has been changed from its natural condition by excavation or other means.

DIVERSION CHAMBER DIVERSION CHAMBER

A chamber or box which contains a device for diverting or drawing off all or part of a flow or for discharging portions of the total flow to various outlets. Also called a REGULATOR.

DOMESTIC DOMESTIC

Residential living facilities. A domestic area will be predominantly residential in occupancy and is sometimes referred to as a "bedroom area" or "bedroom community."

DOMESTIC CONTRIBUTION DOMESTIC CONTRIBUTION

Wastes originating in a residential facility or dwelling. In this use, it means the type and quantity of wastes are different from commercial and industrial or agricultural wastes.

DOMESTIC SERVICE DOMESTIC SERVICE

A connection to a sewer system for hookup of a residential-type building.

DOWNSPOUT DOWNSPOUT

In plumbing, the water conductor from the roof gutters or roof catchment to the storm drain or other means of disposal. Also called a "roof leader", or "roof drain."

DOWNSTREAM DOWNSTREAM

The direction of the flow of water. In the lower part of a sewer or collection system or in that direction.

DRAGLINE DRAGLINE

A machine that drags a bucket down the intended line of a trench to dig or excavate the trench. Also used to dig holes and move soil or aggregate.

DROP JOINT DROP JOINT

A sewer pipe joint where one part has dropped out of alignment. Also called a VERTICAL OFFSET.

DROP MANHOLE DROP MANHOLE

(1) A shaft in which wastewater is allowed to fall or drop from a higher level to the bottom (invert) of the manhole.

(2) In some manholes with drop lines, a connection is made to the line outside of the manhole and the flow is conducted down to the invert or trough of the manhole through this connection.

DRY PIT DRY PIT

(See DRY WELL)

DRY WELL DRY WELL

A dry room or compartment in a lift station, near or below the water level, where the pumps are located.

DWELLING DWELLING

A structure for residential occupancy.

DYNAMIC HEAD DYNAMIC HEAD

When a pump is operating, the vertical distance (in feet) from a point to the energy grade lines. Also see TOTAL DYNAMIC HEAD, STATIC HEAD, and ENERGY GRADE LINE.

E

EARTH SHIFT EARTH SHIFT

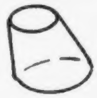
The movement or dislocation of underground soil or structure. Earth shift is usually caused by external forces such as surface loads, slides, stresses or nearby construction, water movements or seismic forces.

EASEMENT EASEMENT

Legal right to use the property of others for a specific purpose. For example, a utility company may have a five-foot easement along the east property line of a home. This gives the utility the legal right to install and maintain a sewer line within the easement.

ECCENTRIC MANHOLE CONE ECCENTRIC MANHOLE CONE

Cone tapers nonuniformly from barrel to manhole cover with one side usually vertical.



EFFLUENT (EF-lou-ent) EFFLUENT

Wastewater or other liquid — raw, partially or completely treated — flowing *FROM* a basin, treatment process, or treatment plant.

ELBOW ELBOW

A pipe fitting that connects two pipes at an angle. The angle is always 90 degrees unless another angle is stated. Also called an ELL.

ELECTROLYTE SOLUTION (e-LECK-tro-light) ELECTROLYTE SOLUTION

A special solution that is capable of conducting electricity.

ELECTROMOTIVE FORCE (E.M.F.) ELECTROMOTIVE FORCE (E.M.F.)

The electrical pressure available to cause a flow of current (amperage) when an electrical circuit is closed. See VOLTAGE.

ELECTRON ELECTRON

A very small, negatively-charged particle which is practically weightless. According to the electron theory, all electrical and electronic effects are caused either by the movement of electrons from place to place or because there is an excess or lack of electrons at a particular place.

ELEVATION ELEVATION

The height to which something is elevated, such as the height above sea level.

EMULSION (e-MULL-shun) EMULSION

A liquid mixture of two or more liquid substances not normally dissolved in one another; one liquid is held in suspension in the other.

ENCLOSED SPACE ENCLOSED SPACE

(See CONFINED SPACE)

ENERGY GRADE LINE (E.G.L.) ENERGY GRADE LINE (E.G.L.)

A line that represents the elevation of energy head of water flowing in a pipe, conduit or channel. The line is drawn above the hydraulic grade line a distance equal to the velocity head of the water flowing at each section or point along the pipe or channel.

ESTIMATED CONTRIBUTION ESTIMATED CONTRIBUTION

A contribution to a collection system that is estimated rather than computed. The distinction between computed and estimated in such cases is difficult to specify or define. Also see COMPUTED CONTRIBUTION.

ESTIMATED FLOW ESTIMATED FLOW

A rough guess of the amount of flow in a collection system. When greater accuracy is needed, flow could be computed using average or typical flow quantities. Even greater accuracy would result from metering or otherwise measuring the actual flow.

EXFILTRATION (EX-fill-TRAY-shun) EXFILTRATION

Liquid wastes and liquid-carried wastes which unintentionally leak out of a sewer pipe system and into the environment.

EXTRADOS EXTRADOS

The upper outside curve of a sewer pipe or conduit.

EXTREMELY HAZARDOUS WASTE EXTREMELY HAZARDOUS WASTE

Any hazardous waste or mixture of hazardous wastes which, if any human exposure should occur, may likely result in death, disabling personal injury or illness during, or as approximate result of, any disposal of such waste or mixture of wastes because of its quantity, concentration, or chemical characteristics. (Subsection 23115 of Article 2, Chapter 6.5, Division 20 of the California Health and Safety Code.) Also see HAZARDOUS WASTE.

F

FAIR LEAD PULLEY (fair-LEE-d-pully) FAIR LEAD PULLEY

A pulley that is placed in a manhole to guide a TV camera, electric cables, and the pull cable into the sewer when inspecting pipelines.

FAULT FAULT

(1) A fracture in the earth's crust that leaves land on one side of the crack out of alignment with the other side. Faults are generally a result of earth shifts and earthquakes.

(2) (See DEFECT)

FILLED DIP FILLED DIP

(See DIP)

FLAP GATE FLAP GATE

A hinged gate that is mounted at the top of a pipe or channel to allow flow in only one direction. Flow in the wrong direction closes the gate. Also see Check Valve and Tide Gate.

FLOAT (CONTROL) FLOAT (CONTROL)

A device used to measure the elevation of the surface of water. The float rests on the surface of the water and rises or falls with it. The elevation of the water surface is measured by a rod, chain, rope or tape attached to the float.

FLOAT LINE FLOAT LINE

A length of rope or heavy twine attached to a float, plastic jug or parachute to be carried by the flow in a sewer from one manhole to the next. This is called "stringing the line" and is used for pulling through winch cables, such as for bucket machine work or closed-circuit television work.

FLOTATION FLOTATION

(1) The stress or forces on a pipeline or manhole structure located below a water table which tend to lift or float the pipeline or manhole structure.

(2) The process of raising suspended matter to the surface of the liquid in a tank where it forms a scum layer that can be removed by skimming. The suspended matter is raised by aeration, the evolution of gas, the use of chemicals, electrolysis, heat or bacterial decomposition.

FLOTSAM (FLOAT-sam) FLOTSAM

(See SURFACE SOLIDS)

FLOW FLOW

The continuous movement of a liquid from one place to another.

FLOW ISOLATION FLOW ISOLATION

A procedure used to measure inflow and infiltration (I/I). A section of sewer is blocked off or isolated and the flow from the section is measured.

FLOW LINE FLOW LINE

(1) The top of the wetted line, the water surface or the hydraulic grade line of water flowing in an open channel or partially full conduit.

(2) The lowest point of the channel inside a pipe or manhole. See INVERT. *NOTE:* (2) is an improper definition, although used by some contractors.

FLOW RECORDING FLOW RECORDING

A record of a flow measurement past any selected point. Usually consists of time, velocity and amount (in gallons) with maximum and minimum rates as well as the total amount over a given time period.

FLUME FLUME

An open conduit of wood, masonry, metal, or plastic constructed on a grade and sometimes elevated. Sometimes called an "aqueduct" or "channel."

FLUME, PARSHALL FLUME, PARSHALL

(See PARSHALL FLUME)

FLUSHER BRANCH FLUSHER BRANCH

A line built specifically to allow the introduction of large quantities of water to the collection system so the lines can be "flushed out" with water. Also installed to provide access for equipment to clear stoppages in a sewer.

FLUSHING FLUSHING

The removing of deposits of material which have lodged in sewers because of inadequate velocity of flows. Water is discharged into the sewers at such rates that the larger flow and higher velocities are sufficient to remove the material.

FOCAL LENGTH FOCAL LENGTH

The distance of a focus from the surface of a lens (such as a camera lens) to the focal point.

FORCE MAIN FORCE MAIN

A pipe that carries wastewater under pressure from the discharge side of a pump to a point of gravity flow downstream.

FRIABILITY (FRY-ability) FRIABILITY

The ability of a soil or substance to crumble under moderate or light pressure.

FRICTION LOSS FRICTION LOSS

The head lost by water flowing in a stream or conduit as the result of the disturbances set up by the contact between the moving water and its containing conduit and by intermolecular friction.

FULL DIP FULL DIP

(See DIP)

FUSE FUSE

A protective device having a strip or wire of fusible metal which, when placed in a circuit, will melt and break the electrical circuit if heated too much. High temperatures will develop in the fuse when a current flows through the fuse in excess of that which the circuit will carry safely.

G

GAGE GAGE

A device for checking or measuring a particular dimension of something, using specific standardized units. For example, a gage might measure the elevation of a water surface, the velocity of flowing water, the pressure of water, the amount or intensity of precipitation, and the depth of snowfall. Gages also are used to determine the location or position of equipment during installation and after operation.

GAS (SEWER) GAS (SEWER)

(See SEWER GAS)

GEL OR GELL GEL OR GELL

(1) A term sometimes applied to chemical grout. See CHEMICAL GROUT.

(2) A form of matter in a colloidal state that does not dissolve, but remains suspended in a solvent. It does not precipitate out of the solvent without the intervention of heat or of an electrolyte.

GEOLOGY GEOLOGY

The science that deals with the origin, history and structures of the earth, as recorded in the rocks, together with the forces and processes now operating to modify rocks.

GEOLOGY, SUBSOIL GEOLOGY, SUBSOIL

(See SUBSOIL GEOLOGY)

GEOLOGY, SUBSTRUCTURE GEOLOGY, SUBSTRUCTURE

(See SUBSOIL GEOLOGY)

GPCD GPCD

Initials standing for "Gallons Per Capita per Day."

GPD GPD

Initials standing for "Gallons Per Day."

GPM GPM

Initials standing for "Gallons Per Minute."

GPY GPY

Initials standing for "Gallons Per Year."

GRADE GRADE

(1) The elevation of the invert of the bottom of a pipeline, canal, culvert, sewer, or similar conduit.

(2) The inclination or slope of a sewer, conduit, stream channel, or natural ground surface, usually expressed in terms of the ratio or percentage of number of units of vertical rise or fall per unit of horizontal distance. A 0.5 percent grade would be a drop of one-half foot per hundred feet of pipe.

GRANULAR GRANULAR

Any substance that appears to consist of separate granules or grains. Examples are sand and gravel.

GRAVITY GRAVITY

The attraction of the earth to any substance — solid, liquid or gas.

GRAVITY FLOW GRAVITY FLOW

Water or wastewater flowing from a higher elevation to a lower elevation due to the force of gravity. The water does not flow due to energy provided by a pump. Wherever possible, wastewater collection systems are designed to use the force of gravity to convey waste liquids and solids.

GRAVITY, SPECIFIC GRAVITY, SPECIFIC

(See SPECIFIC GRAVITY)

GREASE GREASE

In a collection system, grease is considered to be the residues of fats, detergents, waxes, free fatty acids, calcium and magnesium soaps, mineral oils, and certain other nonfatty materials which tend to separate from water and coagulate as floatables or scums.

GREASE BUILDUP GREASE BUILDUP

Any point in a collection system where coagulated and solidified greases accumulate and build up. Many varieties of grease have high adhesive characteristics and collect other solids, forming restrictions and stoppages in collection systems.

GREASE TRAP GREASE TRAP

A receptacle designed to collect and retain grease and fatty substances usually found in kitchens or from similar wastes. It is installed in the drainage system between the kitchen or other point or production of the waste and the building wastewater collection line.

GRIT GRIT

The heavy mineral material present in wastewater such as sand, coffee grounds, eggshells, gravel and cinders. Grit tends to settle out at flow velocities below 2 ft/sec and accumulate in the invert or bottoms of the pipelines.

GRIT CATCHER GRIT CATCHER

A chamber usually placed at the upper end of a depressed collection line or at other points on combined or storm collection lines where wear from grit is possible; the chamber is sized and shaped to reduce the velocity of flow through it and thus permit the settling out of grit. Also called "sand catcher." See GRIT CHAMBER and SAND TRAP.

GRIT CHAMBER GRIT CHAMBER

A detention chamber or an enlargement of a collection line designed to reduce the velocity of flow of the liquid to permit the separation of mineral from organic solids by differential sedimentation.

GRIT CHANNEL GRIT CHANNEL

(1) An enlargement in a collection line where grit can easily settle out of the flow.

(2) The waterway of a grit chamber.

GRIT COLLECTOR GRIT COLLECTOR

A device placed in a grit chamber to convey deposited grit to a point of collection.

GRIT COMPARTMENT GRIT COMPARTMENT

The portion of the grit chamber in which grit is collected and stored before removal.

GRIT SEPARATOR GRIT SEPARATOR

A device located at the inlet to a treatment plant for the accumulation and removal of grit.

GRIT TRAP GRIT TRAP

(1) A permanent structure built into a manhole (or other convenient location in a collection system) for the accumulation and easy removal of grit.

(2) (See SAND TRAP)

GROUNDWATER GROUNDWATER

Subsurface water in the saturation zone from which wells and springs are fed. In a strict sense the term applies only to water below the water table. Also called "phreatic water" and "plerotic water."

GROUNDWATER DEPTH GROUNDWATER DEPTH

The distance of the groundwater table below the surface at any selected location.

GROUNDWATER ELEVATION GROUNDWATER ELEVATION

The elevation of the groundwater table above mean sea level at any selected location.

GROUNDWATER TABLE GROUNDWATER TABLE

The average depth or elevation of the groundwater over a selected area.

GROUNDWATER TABLE, ARTIFICIAL GROUNDWATER TABLE, ARTIFICIAL

(See ARTIFICIAL GROUNDWATER TABLE)

GROUNDWATER TABLE, SEASONAL GROUNDWATER TABLE, SEASONAL

(See SEASONAL GROUNDWATER TABLE)

GROUNDWATER TABLE, TEMPORARY GROUNDWATER TABLE, TEMPORARY

(See TEMPORARY GROUNDWATER TABLE)

GROUT GROUT

A substance in a paste or liquid form which solidifies after placement or treatment. Used to fill spaces, holes or voids in other materials.

GROUT, CHEMICAL GROUT, CHEMICAL

(See CHEMICAL GROUT)

GROUTING, PRESSURE GROUTING, PRESSURE

(See CHEMICAL GROUTING)

GUNITE GUNITE

A mixture of sand and cement applied pneumatically that forms a high density, resistance concrete.

H

HAIRLINE CRACK HAIRLINE CRACK

A stress crack in a pipe that looks like a piece of hair.

HAND ROD HAND ROD

A sewer rod that can be inserted manually (by hand) into a sewer to clear a stoppage or to prevent a stoppage from developing.

HANDHOLE TRAP HANDHOLE TRAP

A device made of pipe fittings used to prevent sewer gases escaping from the branch or lateral sewer from entering a building sewer.

HAZARDOUS WASTE HAZARDOUS WASTE

Any waste material or mixture of wastes which is toxic, corrosive, flammable, an irritant, a strong sensitizer which generates pressure through decomposition, heat or other means, if such a waste or mixture of wastes may cause substantial personal injury, serious illness or harm to wildlife, during, or as approximate result of any disposal of such wastes or mixture of wastes. The terms "toxic," "corrosive," "flammable," "irritant," and "strong sensitizer" shall be given the same meanings as given by the California Hazardous Substance Act (Chapter 13 (commencing with Section 28740) of Division 21) (Subsection 23117 of Article 2, Chapter 6.5, Division 20 of the California Health and Safety Code). Also see EXTREMELY HAZARDOUS WASTE.

HEAD HEAD

A term used to describe the height or energy of water above a point. A head of water may be measured in either height (feet) or pressure (pounds per square inch (psi)). Also see DISCHARGE HEAD, DYNAMIC HEAD, STATIC HEAD, SUCTION HEAD, SUCTION LIFT, and VELOCITY HEAD.

HERTZ (HURTS) HERTZ

The number of complete electromagnetic cycles or waves in one second of an electrical or electronic circuit. Also called the frequency of the current. Abbreviated Hz.

HIGH VELOCITY CLEANER HIGH VELOCITY CLEANER

A machine designed to remove grease and debris from the smaller diameter sewer pipes with jets of high velocity water. Also called a "jet cleaner," "jet rodder," "hydraulic cleaner," or "high pressure cleaner."

HOUSE CONNECTION HOUSE CONNECTION

(See BUILDING SEWER)

HOUSE SERVICE HOUSE SERVICE

(See BUILDING SERVICE)

HOUSE SEWER HOUSE SEWER

(See BUILDING SEWER)

HUB HUB

In pipe fitting, the enlarged female end of a pipe into which the male end fits. Also called a BELL.

HYDRAULIC BLOCK HYDRAULIC BLOCK

The movement of water in such a way that the flow of water from one direction blocks or hinders the flow of water from another direction.

HYDRAULIC CLEANER HYDRAULIC CLEANER

(See HIGH VELOCITY CLEANER)

HYDRAULIC CLEANING HYDRAULIC CLEANING

Cleaning pipe with water under enough pressure to produce high water velocities.

(1) Using a high velocity cleaner.
(2) Using a ball, kite or similar sewer-cleaning device.
(3) Using a scooter.
(4) Flushing.

HYDRAULIC GRADE LINE (H.G.L.) HYDRAULIC GRADE LINE (H.G.L.)

The surface or profile of water flowing in an open channel or a pipe flowing partially full. If a pipe is under pressure, the hydraulic grade line is at the level water would rise to in a small tube connected to the pipe. To reduce the release of odors from sewers, the water surface or hydraulic grade line should be kept as smooth as possible.

HYDRAULIC POPULATION EQUIVALENT HYDRAULIC POPULATION EQUIVALENT

A flow of 100 gallons per day is the hydraulic or flow equivalent to the contribution or flow from one person. Population equivalent = 100 gpcd or gallons per capita per day.

HYDROGEN SULFIDE GAS (H_2S) HYDROGE SULFIDE GAS (H_2S)

Hydrogen sulfide is a gas with a rotten egg odor. This gas is produced under anaerobic conditions. Hydrogen sulfide is particularly dangerous because it dulls your sense of smell so that you don't notice it after you have been around it for a while and because the odor is not noticeable in high concentrations. The gas is very poisonous to your respiratory system, explosive and flammable.

HYDROLOGY HYDROLOGY

The applied science concerned with the waters of the earth in all their states — their occurrence, distribution, and circulation through the unending hydrologic cycle of precipitation, consequent runoff, stream flow, infiltration, and storage, eventual evaporation, and reprecipitation. Hydrology is concerned with the physical, chemical, and physiological reactions of water with the rest of the earth and its relation to the life of the earth.

HYDROPHILIC HYDROPHILIC

Water loving.

I

IMPELLER IMPELLER

A rotating set of vanes in a pump designed to pump or lift water.

IMPORTED BACKFILL IMPORTED BACKFILL

Material used for backfilling a trench or excavation which was not the original material removed during excavation. This is a common practice where tests on the original material show it to have poor compactability or load capacity. Also called BORROW BACKFILL.

INDUSTRIAL TELEVISION EQUIPMENT INDUSTRIAL TELEVISION EQUIPMENT

(See INSPECTION TELEVISION CAMERA)

INDUSTRIAL WASTEWATER INDUSTRIAL WASTEWATER

Liquid wastes originating from industrial processing. Because industries have peculiar liquid waste characteristics requiring special consideration, these sources are usually handled and treated separately.

INFILTRATED DEBRIS INFILTRATED DEBRIS

Sand, silt, gravel and rocks carried or washed into a collection system by infiltration water flows.

INFILTRATION (IN-fill-TRAY-shun) INFILTRATION

The water entering a sewer pipe, including service connections, from the ground. Defective pipes, pipe joints, connections or manhole walls are a few of the common locations where infiltration may occur.

INFILTRATION/INFLOW INFILTRATION/INFLOW

The total quantity of water from both infiltration and inflow without distinguishing the source.

INFILTRATION HEAD INFILTRATION HEAD

The distance from a point of infiltration leaking into a collection system to the water table elevation. This is the pressure of the water being forced through the leak in the collection system.

INFILTRATION PRESSURE INFILTRATION PRESSURE

(See INFILTRATION HEAD)

INFILTRATION, TEMPORARY INFILTRATION, TEMPORARY

(See TEMPORARY INFILTRATION)

INFLATABLE PIPE STOPPER INFLATABLE PIPE STOPPER

An inflatable ball or bag used to form a plug to stop flows in a sewer pipe.

INFLOW INFLOW

The water discharged into a sewer system and service connections from such sources as, but not limited to, roof leaders, cellar, yard and area drains, foundation drains, cooling water discharges, drains from springs and swampy areas, around manhole covers or through holes in the covers, cross connections from storm and combined sewer systems, catch basins, storm waters, surface runoff, street wash waters or drainage. See INTERNAL FLOW.

INFLUENT INFLUENT

Wastewater or other liquid — raw or partially treated — flowing *INTO* a reservoir, basin, treatment process, or treatment plant.

INLET INLET

(1) A surface connection to a drain pipe.

(2) A chamber for collecting storm water with no well below the outlet pipe for collecting grit. Often connected to a CATCH BASIN or a "basin manhole" ("cleanout manhole") with a grit chamber.

INORGANIC WASTE INORGANIC WASTE

Waste material such as sand, salt, iron, calcium, and other mineral materials which are only slightly affected by the action of organisms. Inorganic wastes are chemical substances of mineral origin; whereas organic wastes are chemical substances usually of animal or vegetable origin.

INSPECTION TELEVISION EQUIPMENT INSPECTION TELEVISION EQUIPMENT

Television equipment that is superior to standard commercial quality, providing 600 to 650 lines of resolution, and designed for industrial inspection applications. Also known as INDUSTRIAL TELEVISION EQUIPMENT.

INTERCEPTING SEWER INTERCEPTING SEWER

A sewer that receives flow from a number of other large sewers or outlets and conducts the waters to a point for treatment or disposal. Often called an "interceptor."

INTERCONNECTOR INTERCONNECTOR

A sewer installed to connect two separate sewers. If one sewer becomes blocked, wastewater can back up and flow through the interconnector to the other sewer.

INTERNAL INFLOW INTERNAL INFLOW

Non-sanitary or industrial wastewaters generated inside of a domestic, commercial or industrial facility and being discharged into the sewer system. Examples are cooling tower waters, basement sump pump discharge waters, continuous-flow drinking fountains, and defective or leaking plumbing fixtures.

INTRADOS INTRADOS

The upper inside curve or surface of a sewer pipe or conduit.

INVERSION INVERSION

An Insituform process in which the insitutube or liner is turned inside out (inverted) during the installation of the liner.

INVERT INVERT

The lowest point of the channel inside a pipe or manhole. See FLOW LINE.

INVERTED SIPHON INVERTED SIPHON

A pressure pipeline used to carry wastewater flowing in a gravity collection system under a depression such as a valley or roadway or under a structure such as a building. Also called a DEPRESSED SEWER.

J

JET CLEANER JET CLEANER

(See HIGH VELOCITY CLEANER)

JET RODDER JET RODDER

(See HIGH VELOCITY CLEANER)

JETSAM (JET-sam) JETSAM

Debris entering a collection system which is heavier than water. Also see GRIT.

JOINT JOINT

A connection between two lengths of pipe, made either with or without the use of another part.

K

KEY MANHOLE KEY MANHOLE

In collection system evaluation, a key manhole is one from which reliable or specific data can be obtained.

KITE KITE

A device for hydraulically cleaning sewer lines. Resembling an airport wind sock and constructed of canvas-type material, the kite increases the velocity of a flow at its outlet to wash debris ahead of it.

L

LAMP HOLE LAMP HOLE

A small vertical pipe or shaft extending from the surface of the ground to a sewer. A light (or lamp) may be lowered down the pipe for the purpose of inspecting the sewer. Rarely constructed today.

LAMPING LAMPING

Using reflected sunlight or a powerful light beam to inspect a sewer between two adjacent manholes. The light is directed down the pipe from one manhole. If it can be seen from the next manhole, it indicates that the line is open and straight.

LATERAL LATERAL

(See BUILDING LATERAL)

LATERAL BREAK LATERAL BREAK

A break in a lateral pipe somewhere between the sewer main and the building connection.

LATERAL CLEANOUT LATERAL CLEANOUT

A capped opening in a building lateral, usually located on the property line, through which the pipelines can be cleaned.

LATERAL CONNECTION LATERAL CONNECTION

(See BUILDING SERVICE)

LATERAL SEWER LATERAL SEWER

A sewer that discharges into a branch or other sewer and has no other common sewer tributary to it. Sometimes called a "street sewer" because it collects wastewater from individual homes.

LEAD (LEE-d) LEAD

A wire or conductor that can carry electrical current.

LIFE-CYCLE COSTING LIFE-CYCLE COSTING

An economic analysis procedure that converts all costs associated with a sewer during its useful life to a present worth or present cost in dollars.

LIFT STATION LIFT STATION

A wastewater pumping station that lifts the wastewater to a higher elevation when continuing the sewer at reasonable slopes would involve excessive depths of trench. Also, an installation of pumps that raise wastewater from areas too low to drain into available sewers. These stations may be equipped with air-operated ejectors or centrifugal pumps. Sometimes called a PUMP STATION, but this term is usually reserved for a similar type of facility that is discharging into a long FORCE MAIN, while a lift station has a discharge line or force main only up to the downstream gravity sewer. Throughout this manual when we refer to lift stations, we intend to include pump stations.

LINER LINER

(See PIPE LINER)

LIQUID VEHICLE LIQUID VEHICLE

Water in a collection system that is used to carry non-liquid wastes. The standard toilet provides around seven gallons of water per flush as a vehicle to carry wastes through the pipe system.

LIQUOR LIQUOR

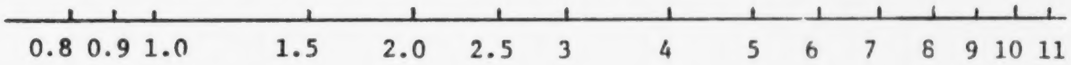
Water, wastewater, or any combination; commonly used to mean the liquid portion when other wastes are also present.

LOGARITHM (LOG-a-rith-m) LOGARITHM

The exponent that indicates the power to which a number must be raised to produce a given number. For example: if $B^2 = N$, then 2 is the logarithm of N (to the base B), or $10^2 = 100$ and $\log_{10} 100 = 2$.

LOGARITHMIC SCALE (LOG-a-rith-mick) LOGARITHMIC SCALE

A scale on which actual distances from the origin are proportional to the logarithms of the corresponding scale numbers rather than to the numbers themselves. A logarithmic scale has the numbers getting bigger as the distances between the numbers decreases.



LONGITUDINAL CRACK (LAWN-ji-TWO-da-null) LONGITUDINAL CRACK

A crack in a pipe or pipe section that runs lengthwise along the pipe.

LUBRIFLUSHING (LOOB-rah-FLUSH-ing) LUBRIFLUSHING

A method of lubricating bearings with grease. Remove the relief plug and apply the proper lubricant to the bearing at the lubrication fitting. Run the pump to expel excess lubricant.

M

M-ZONED M-ZONED

An area set aside for manufacturing and industry.

MAIN LINE MAIN LINE

Branch or lateral sewers that collect wastewater from building sewers and service lines.

MAIN SEWER MAIN SEWER

A sewer line that receives wastewater from many tributary branches and sewer lines and serves as an outlet for a large territory or used to feed an intercepting sewer.

MANDREL (MAN-drill) MANDREL

(1) A special tool used to push bearings in or to pull sleeves out.

(2) A gage used to measure for excessive deflection in a flexible conduit.

MANHOLE MANHOLE

An opening in a sewer provided for the purpose of permitting operators or equipment to enter or leave a sewer. Sometimes called an "access hole."

MANHOLE BEDDING MANHOLE BEDDING

The prepared and compacted base on which a manhole is constructed.

MANHOLE DEPTH MANHOLE DEPTH

The measurement from the top of the manhole opening to the invert or lowest point of the trough at the bottom of the manhole.

MANHOLE, DROP **MANHOLE, DROP**

(See DROP MANHOLE)

MANHOLE ELEVATION **MANHOLE ELEVATION**

The height (elevation) of the invert or lowest point in the bottom of a manhole above mean sea level.

MANHOLE FLOW **MANHOLE FLOW**

(1) The depth or amount of wastewater flow in a manhole as observed at any selected time.

(2) The total or the average flow through a manhole in gallons in any selected time interval.

MANHOLE FRAME **MANHOLE FRAME**

A metal ring or frame with a ledge to accommodate the manhole lid; located at the surface of the ground or street. Also called a MANHOLE RING.

MANHOLE INFILTRATION **MANHOLE INFILTRATION**

Groundwaters seeping or leaking into a manhole structure.

MANHOLE INFLOW **MANHOLE INFLOW**

Surface waters flowing into a manhole, usually through the vent holes in the manhole lid.

MANHOLE INVERT **MANHOLE INVERT**

The lowest point in a trough or flow channel in the bottom of a manhole.

MANHOLE, KEY **MANHOLE, KEY**

(See KEY MANHOLE)

MANHOLE LID **MANHOLE LID**

The heavy cast iron or forged steel cover of a manhole. The lid may or may not have vent holes.

MANHOLE LID DUST PAN **MANHOLE LID DUST PAN**

A sheet metal or cast iron pan located under a manhole lid. This pan serves to catch and hold pebbles and other debris falling through vent holes, preventing them from getting into the pipe system.

MANHOLE RING **MANHOLE RING**

A metal frame or ring with a ledge to accommodate the lid and located at the surface of the ground or street. Also called a MANHOLE FRAME.

MANHOLE SEALING **MANHOLE SEALING**

The process of sealing up infiltration leaks in a manhole by injecting chemical grout.

MANHOLE, SURCHARGED **MANHOLE, SURCHARGED**

(See SURCHARGED MANHOLE)

MANHOLE TOOLS **MANHOLE TOOLS**

(1) Special tools having conveniently short handles for working inside manholes.

(2) Special long-handled or extendable tools for removal of debris and other objects from manholes without requiring a person to enter the manhole.

MANHOLE TROUGH **MANHOLE TROUGH**

The channel in the bottom of a manhole for the flow of the wastewater from manhole inlet to outlet.

MANHOLE VENTS **MANHOLE VENTS**

One or a series of one-inch diameter holes through a manhole lid for purposes of venting off dangerous gases found in sewers.

MANNING'S FORMULA MANNING'S FORMULA

A mathematical formula for calculating wastewater flows in sewers.

$$Q = \frac{1.49}{n} A R^{2/3} S^{1/2}$$

Q means flow in cubic feet per second (cfs).
N means the Manning pipe or channel roughness factor.
A means the cross-sectional area of the flow in square feet (sq ft).
R means the hydraulic radius in feet (ft) where R equals A/P. P is the wetted perimeter of the channel or pipe in feet.
S means the slope of the channel or energy grade line in feet per foot (ft/ft)

MANNING'S TABLES MANNING'S TABLES

A set of tables for finding wastewater flows in sewers.

MANOMETER (man-NOM-muh-ter) MANOMETER

Usually a glass tube filled with a liquid and used to measure the difference in pressure across a flow-measuring device such as an orifice or a venturi meter.

MEASURED FLOW MEASURED FLOW

A flow which has been physically measured. See GAGE.

MECHANICAL CLEANING MECHANICAL CLEANING

Clearing pipe by using equipment that scrapes, cuts, pulls or pushes the material out of the pipe. Mechanical cleaning devices or machines include bucket machines, power rodders and hand rods.

MECHANICAL PLUG MECHANICAL PLUG

A pipe plug used in sewer systems that is mechanically expanded to create a seal.

MEGGER (from "megohm") MEGGER

An instrument used for checking the insulation resistance on motors, feeders, buss bar systems, grounds, and branch circuit wiring.

METERED METERED

Measured through a meter, as a quantity of water or flow might be measured.

MG MG

Initials for "Million Gallons."

MGD MGD

Initials for "Million Gallons per Day."

mg/*L* mg/*L*

Intials for "Milligrams per Liter." A measure of the concentration by weight of a substance per unit volume in water or wastewater. In reporting the results of water and wastewater analysis, mg/*L* is preferred to the unit parts per million (ppm), to which it is approximately equivalent.

MGY MGY

Initials for "Million Gallons per Year."

MICROORGANISMS (micro-ORGAN-is-zums) MICROORGANISMS

Very small organisms that can be seen only through a microscope. Some microorganisms use the wastes in wastewater for food and thus remove or alter much of the undesirable matter.

MILLION GALLONS MILLION GALLONS

A unit of measurement used in wastewater treatment plant design and collection system capacities or performances.

One million gallons of water is approximately equivalent to:

13,690	Cubic Feet
3.07	Acre-Feet
8,340,000	Pounds of Weight
3,723	Tons of Weight
3,785	Cubic Meters

MINERAL MINERAL

Any substance that is neither animal nor vegetable. Minerals include sand, salt, iron, calcium, and nutrients.

MINERAL CONTENT MINERAL CONTENT

The quantity of dissolved minerals in a sample of water.

MONITOR MONITOR

(1) (See CONDUCTOR)

(2) (See TELEVISION MONITOR)

N

"N" FACTOR "N" FACTOR

A coefficient value representing the pipe or channel roughness in Manning's formula for computing flows in gravity sewers. See FRICTION LOSS and MANNING'S FORMULA.

NET WASTEWATER CONTRIBUTION NET WASTEWATER CONTRIBUTION

In a wastewater collection system, the net wastewater contribution consists of the liquid wastes and liquid-carried wastes transported by the pipelines or received by the pipelines. This value would be the only wastewater found in a collection system if all sources of infiltration, inflow and exfiltration were eliminated.

NET WASTEWATER FLOW NET WASTEWATER FLOW

The actual wastewater flow from a collection system that reaches a wastewater treatment plant. The net wastewater flow includes the net wastewater contribution, infiltration and inflow and does not include losses through exfiltration.

NODULAR (NOD-you-lar) NODULAR

Shaped like a rounded lump, knot or knob. An irregular enlargement.

NOMINAL DIAMETER NOMINAL DIAMETER

Approximate diameter of a pipe; used to describe the size or diameter of a pipe.

NOMOGRAPH (NOME-o-graph) NOMOGRAPH

A graphic representation or means of solving an equation or mathematical relationship. Results are obtained with the aid of a straightedge placed over important known values.

NOTE NOTE

This word calls attention to information that is especially significant in understanding and operating the equipment.

O

OSHA OSHA

The Williams-Steiger **O**ccupational **S**afety and **H**ealth **A**ct of 1970 is a law designed to protect the health and safety of industrial workers and collection system operators. The Act regulates the design, construction, operation and maintenance of industrial plants and wastewater collection and treatment facilities. The Act does not apply directly to municipalities at present (1981), *EXCEPT* in those states that have approved plans and have asserted jurisdiction under Section 18 of the OSHA Act. However, wastewater collection systems have come under stricter regulation in all phases of activity as a result of OSHA standards.

OBSTRUCTION OBSTRUCTION

Any solid object in or protruding into a wastewater flow in a collection line that prevents a smooth or even passage of the wastewater.

OFF LINE OFF LINE

A run of sewer pipe between two manholes is said to be "off line" if it is not located directly under a straight line passing through the exact centers of the two manholes. Sewer alignment does not always pass through the center of a manhole, especially at junctions. Also called "misaligned."

OFFSET OFFSET

(1) A combination of elbows or bends which brings one section of a line of pipe out of line with, but into a line parallel with, another section.

(2) A pipe fitting in the approximate form of a reverse curve, made to accomplish the same purpose.

(3) A pipe joint that has lost its bedding support and one of the pipe sections has dropped or slipped, thus creating a condition where the pipes no longer line up properly.

OFFSET INVERT OFFSET INVERT

A trough or channel in the bottom of a manhole which is not centered in the bottom.

OFFSET JOINT OFFSET JOINT

A pipe joint that is not exactly in line and centered. See DROP JOINT and VERTICAL OFFSET.

OFFSET MANHOLE OFFSET MANHOLE

A manhole located to one side of a pipe run with either "Y" connections to it or the inlet and outlet pipes bent to enter and leave the manhole.

OFFSET PIPE OFFSET PIPE

(See OFF LINE)

OFFSET TROUGH OFFSET TROUGH

(1) When the pipe feeding into a manhole does not exactly match up with the pipe leading out of the manhole, the invert channel must be angled or curved. This is referred to as an "offset trough."

(2) (See OFFSET INVERT)

OHM OHM

The unit of electrical resistance. The resistance of a conductor in which one volt produces a current of one ampere.

OLFACTORY FATIGUE (ol-FAK-tory) OLFACTORY FATIGUE

A condition in which a person's nose, after exposure to certain odors, is no longer able to detect the odor.

ORGANIC WASTE ORGANIC WASTE

Waste material which comes from animal or vegetable sources. Organic wastes generally can be consumed by bacteria and other small organisms. (Inorganic wastes are chemical substances of mineral origin.)

ORIFICE (OR-uh-fiss) ORIFICE

An opening in a plate, wall, or partition. An orifice flange set in a pipe consists of a slot or hole smaller than the pipe diameter. The difference in pressure in the pipe above and at the orifice may be related to flow in the pipe.

OUTFALL OUTFALL

(1) The point, location or structure where wastewater or drainage discharges from a sewer, drain, or other conduit.

(2) The conduit leading to the final disposal area. See OUTFALL SEWER.

OUTFALL SEWER OUTFALL SEWER

A sewer that receives wastewater from a collection system or from a wastewater treatment plant and carries it to a point of ultimate or final discharge in the environment. See OUTFALL.

OUTLET OUTLET

Downstream opening or discharge end of a pipe, culvert, or canal.

OVERFLOW MANHOLE OVERFLOW MANHOLE

A manhole which fills and allows raw wastewater to flow out onto the street or ground.

OVERFLOW RELIEF LINE OVERFLOW RELIEF LINE

Where a system has overload conditions during peak flows, an outlet above the invert, leading to a less loaded manhole or part of the system may be installed. This is usually called an "overflow relief line." Also see CROSS CONNECTION (2).

OXIDATION (ox-i-DAY-shun) OXIDATION

The addition of oxygen, removal of hydrogen, or the removal of electrons from an element or compound. In wastewater treatment, organic matter is oxidized to more stable substances.

OXIDATION-REDUCTION POTENTIAL OXIDATION-REDUCTION POTENTIAL

The electrical potential required to transfer electrons from one compound or element (the oxidant) to another compound or element (the reductant) and used as a qualitative measure of the state of oxidation in wastewater treatment systems.

OXYGEN DEFICIENCY OXYGEN DEFICIENCY

An atmosphere containing oxygen at a concentration of less than 19.5 percent by volume.

P

PACKER PACKER

(See CHEMICAL GROUTING)

PACKING RING PACKING RING

A ring made of asbestos or metal which may be lubricated with Teflon or graphite that forms a seal between the pump shaft and its casing.

PARACHUTE PARACHUTE

A device used to catch wastewater flow to pull a float line between manholes. See FLOAT LINE.

PARSHALL FLUME PARSHALL FLUME

A specially constructed flume or channel used to measure flows in open channels.

PATHOGENIC ORGANISMS (PATH-o-JEN-nick OR-gan-iz-ums) PATHOGENIC ORGANISMS

Bacteria, viruses, or cysts which can cause disease (typhoid, cholera, dysentery). There are many types of bacteria which do *NOT* cause disease and which are *NOT* called pathogenic. Many beneficial bacteria are found in wastewater treatment processes actively cleaning up organic wastes.

PEAKING FACTOR PEAKING FACTOR

Ratio of a maximum flow to the average flow, such as maximum hourly flow or maximum daily flow to the average daily flow.

PERCOLATION (PURR-ko-LAY-shun) PERCOLATION

The movement or flow of water through soil or rocks.

PHOTOGRAPHIC INSPECTIONS PHOTOGRAPHIC INSPECTIONS

A method of obtaining photographs of a pipeline by pulling a time-lapse motion picture camera through the line. By moving the camera a specific distance at timed intervals, a sequence of photographs covering the full length of the line is obtained.

PHOTOGRAPHIC RECORDS PHOTOGRAPHIC RECORDS

(1) The film strip from a photographic inspection.

(2) Still camera photographs of a sewer television inspection monitor.

PIPE BEDDING PIPE BEDDING
(See BEDDING and BEDDING GRADE)

PIPE BUCKET PIPE BUCKET

(See BUCKET and BUCKET MACHINE)

PIPE CAPACITY PIPE CAPACITY

In a gravity flow sewer system, pipe capacity is the total amount in gallons a pipe is able to pass in a specific time period.

PIPE CLEANING PIPE CLEANING

Removing grease, grit, roots and other debris from a pipe run by means of one of the hydraulic cleaning methods. (See BALLING, HYDRAULIC CLEANING and KITE)

NOTE: While rodding may be used to open a pipe stoppage or to remove roots and greases, it is not known to remove grit and similar debris.

PIPE DEFLECTION PIPE DEFLECTION

(See DEFLECTION)

PIPE DIAMETER PIPE DIAMETER

The nominal or commercially designated inside diameter of a pipe, unless otherwise stated.

PIPE DIP PIPE DIP

(See DIP)

PIPE DISPLACEMENT PIPE DISPLACEMENT

(1) The cubic inches of soil or water displaced by one foot or one section of pipe.

(2) (See DISPLACED PIPE)

PIPE GRADE PIPE GRADE

The angle of a sewer or a single section of a sewer as installed. Usually expressed in a percentage figure to indicate the drop in feet or tenths of a foot per hundred feet. For example, 0.5 percent grade means a drop of one-half foot per 100 feet of length.

PIPE JACK PIPE JACK

A jack used to fasten roller guides to secure an object within a manhole.

PIPE JOINT PIPE JOINT

A place where two sections of pipe are coupled or joined together.

PIPE JOINT SEAL PIPE JOINT SEAL

(1) The tightness or lack of leakage at a pipe joint.

(2) The method of sealing a pipe coupling.

PIPE LINER PIPE LINER

A plastic liner pulled or pushed into a pipe to eliminate excessive infiltration or exfiltration. Other solutions to the problem of infiltration/exfiltration are the use of cast iron pipe or a cement grouting.

PIPE PLUG PIPE PLUG

(1) A temporary plug placed in a sewer pipe to stop a flow while repair work is being accomplished or other functions are performed.

(2) In construction of a new sewer system, service saddles are sometimes installed before a building or a building lateral is in existence. Under such circumstances, a plug will be placed in the off-lead of the saddle of a "Y". In some instances, this plug may be called a "button" or a "stopper."

PIPE PLUG, INFLATABLE PIPE PLUG, INFLATABLE

(See INFLATABLE PIPE STOPPER)

PIPE PLUG, MECHANICAL PIPE PLUG, MECHANICAL

(See MECHANICAL PLUG)

PIPE RODDING PIPE RODDING

A method of opening a plugged or blocked pipe by pushing a steel rod or snake, or pulling same, through the pipe with a tool attached to the end of the rod or snake. Rotating the rod or snake with a tool attached increases effectiveness.

PIPE RUN PIPE RUN

(1) The length of sewer pipe reaching from one manhole to the next. See BARREL.

(2) Any length of pipe, generally assumed to be in a straight line.

PIPE SEAL PIPE SEAL

(See PIPE JOINT SEAL)

PIPE SEALING PIPE SEALING

(See CHEMICAL GROUTING)

PIPE SECTION PIPE SECTION

A single length of pipe between two joints or couplers.

PIPE SINK PIPE SINK

(See DIP)

PLANT PLANT

(See WASTEWATER TREATMENT PLANT)

PLANT HYDRAULIC CAPACITY PLANT HYDRAULIC CAPACITY

The flow or load, in millions of gallons per day (or fraction thereof), that a treatment plant is designed to handle.

PLANT, TREATMENT PLANT, TREATMENT

(See WASTEWATER TREATMENT PLANT)

PLUG PLUG

(See INFLATABLE PIPE STOPPER and MECHANICAL PLUG)

PNEUMATIC EJECTOR (new-MAT-tik ee-JECK-tor) PNEUMATIC EJECTOR

A device for raising wastewater sludge or other liquid by compressed air. The liquid is alternately admitted through an inward-swinging check valve into the bottom of an airtight pot. When the pot is filled compressed air is applied to the top of the liquid. The compressed air forces the inlet valve closed and forces the liquid in the pot through an outward swinging check valve, thus emptying the pot.

POLLUTION POLLUTION

Any change in the natural state of water which interferes with its beneficial reuse or causes its failure to meet water quality requirements.

POLE SHADER POLE SHADER

Separations on the iron core inside the coil of a magnetic starter.

POLYELECTROLYTE (POLY-electro-light) POLYELECTROLYTE

A high-molecular-weight substance that is formed by either a natural or synthetic process. Natural polyelectrolytes may be of biological origin or derived from starch products, cellulose derivatives, and alignates. Synthetic polyelectrolytes consist of simple substances that have been made into complex, high-molecular-weight substances. Often called a POLYMER.

POLYMER (POLY-mer) POLYMER

A high-molecular-weight substance that is formed by either a natural or synthetic process. Natural polymers may be of biological origin or derived from starch products, cellulose derivatives, and alignates. Synthetic polymers consist of simple substances that have been made into complex, high-molecular-weight substances. Often called a POLYELECTROLYTE.

POPULATION EQUIVALENT (HYDRAULIC) POPULATION EQUIVALENT (HYDRAULIC)

A flow of 100 gallons per day is the hydraulic or flow equivalent to the contribution or flow from one person. Population equivalent = 100 gpcd or gallons per capita per day.

POTABLE WATER (PO-ta-ble) POTABLE WATER

Water that does not contain objectionable pollution, contamination, minerals, or infective agents and is considered satisfactory for domestic consumption.

POWER RODDER POWER RODDER

A sewer-cleaning machine fitted with auger rods which are inserted in a sewer line to dislodge and cut roots and debris.

PPM PPM

Initials for "Parts Per Million." The number of weight or volume units of a minor constituent present with each one million units of the major constituent of a solution or mixture. Used to express the results of most water and wastewater analyses, but more recently milligrams per liter (mg/*L*) is the preferred term.

PRECIPITATION PRECIPITATION

(1) The total measurable supply of water received directly from clouds as rain, snow, hail, or sleet; usually expressed as depth in a day, month, or year, and designated as daily, monthly, or annual precipitation.

(2) The process by which atmospheric moisture is discharged onto a land or water surface.

(3) The separation (of a substance) out in solid form from a solution, as by the use of a reagent.

PRE-CLEANING PRE-CLEANING

Sewer line cleaning, commonly done by high velocity cleaners, that is done prior to TV inspection of a pipeline to remove grease, slime, and grit to allow for a more clear and accurate identification of defects and problems.

PRESSURE GROUTING PRESSURE GROUTING

(See CHEMICAL GROUTING)

PRESSURE HEAD PRESSURE HEAD

(1) The height of a water surface above a specific point of reference. Usually measured in feet and tenths of a foot.

(2) The head represented by the expression of pressure over weight (p/w), where p is pressure (lbs/sq ft) and w is weight (lbs/cu ft).

PRESSURE MAIN PRESSURE MAIN

(See FORCE MAIN)

PREVENTIVE MAINTENANCE PREVENTIVE MAINTENANCE

Regularly scheduled servicing of machinery or other equipment using appropriate tools, tests and lubricants. This type of maintenance can prolong the useful life of equipment and machinery and increase its efficiency by detecting and correcting problems before they cause a breakdown of the equipment.

PROBE PROBE

A T-shaped tool or rod that is pushed or driven down through the soil to locate underground pipes and utility conduits. Also see SOUNDING ROD.

PROMOTED PROMOTED

The mixture of resin and catalyst ready to cause (promote) curing in place.

PROTRUDING SERVICE PROTRUDING SERVICE

The connection of a building lateral to a main sewer line whereby a hole is cut in the main and the end of the building lateral is allowed to extend into the main.

PROTRUDING TAP PROTRUDING TAP

(See PROTRUDING SERVICE)

PUMP PUMP

A mechanical device for causing flow, for raising or lifting water or other fluid, or for applying pressure to fluids.

PUMP PIT PUMP PIT

A dry well, chamber or room below ground level in which a pump is located.

PUMP STATION PUMP STATION

Installation of pumps to lift wastewater to a higher elevation in places where flat land would require excessively deep sewer trenches. Also used to raise wastewater from areas too low to drain into available collection lines. These stations may be equipped with air-operated ejectors or centrifugal pumps. See LIFT STATION.

PUTREFACTION (PEW-tree-FACK-shun) PUTREFACTION

Biological decomposition of organic matter with the production of ill-smelling products associated with anaerobic conditions.

PUTRESCIBLE (pu-TRES-uh-bull) PUTRESCIBLE

Material that will decompose under anaerobic conditions and produce nuisance odors.

Q

QUADRANT QUADRANT

Any of the four more or less equal parts into which something can be divided by two real or imaginary lines that intersect each other at right angles. In television inspection of pipes, for example, the picture of the pipe can be divided into fourths (upper-left, lower-left, upper-right, and lower-right quandrants) to identify the location of observed objects.

QUICK AIR TEST QUICK AIR TEST

The same as a quick test with a packer for chemical grouting except that air pressure is used in place of liquid for a faster test and greater accuracy. Also see CHEMICAL GROUTING.

QUICK TEST QUICK TEST

Use of a packer designed for chemical grouting to pressure test any selected small area of pipeline. Also see CHEMICAL GROUTING.

QUICKSAND QUICKSAND

Sand that has lost its grain-to-grain contact by the buoyancy effect of water flowing upward through the voids. Such material, having some of the characteristics of a fluid, possesses no load-bearing value.

R

"R" FACTOR "R" FACTOR

Refers to pipe or channel "Roughness Factor." See FRICTION LOSS, "N" FACTOR, and ROUGHNESS COEFFICIENT.

R-ZONED R-ZONED

Areas established for residential occupancy.

RAIN RAIN

Particles of liquid water that have become too large to be held by the atmosphere. Their diameter generally is greater than 0.02 inch and they usually fall to the earth at velocities greater than 10 fps in still air. See PRECIPITATION.

RECORDINGS, FLOW RECORDINGS, FLOW

(See FLOW RECORDINGS)

RECORDINGS, PHOTOGRPAHIC RECORDINGS, PHOTOGRAPHIC

(See PHOTOGRAPHIC RECORDS)

RECORDINGS, VIDEO RECORDINGS, VIDEO

(See VIDEO LOG)

RECORDINGS, WRITTEN RECORDINGS, WRITTEN

(See TELEVISION INSPECTION LOG)

REDUCTANT REDUCTANT

A constituent of wastewater or surface waters that uses either free (O_2) or combined oxygen in the process of stabilization.

REGULATOR REGULATOR

A device used in combined sewers to control or regulate the diversion of flow.

RELIEF BY-PASS RELIEF BY-PASS

(See BY-PASS and OVERFLOW RELIEF LINE)

RELIEF LINE RELIEF LINE

(See OVERFLOW RELIEF LINE)

RESISTANCE RESISTANCE

That property of a conductor or wire that opposes the passage of a current, thus causing electrical energy to be transformed into heat.

RETENTION RETENTION

(1) That part of the precipitation falling on a drainage area which does not escape as surface streamflow during a given period. It is the difference between total precipitation and total run-off during the period, and represents evaporation, transpiration, subsurface leakage, infiltration, and, when short periods are considered, temporary surface or underground storage on the area.

(2) The delay or holding of the flow of water and water-carried wastes in a pipe system. This can be due to a restriction in the pipe, a stoppage or a drip. Also, the time water is held or stored in a basin or wet well. This is also called DETENTION.

ROD GUIDE ROD GUIDE

A bent pipe inserted in a manhole to guide hand and power rods into collection lines so the rods can dislodge obstructions.

ROD (SEWER) ROD (SEWER)

A light metal rod, three to five feet long with a coupling at each end. Rods are joined and pushed into a sewer to dislodge obstructions.

RODDING RODDING

(See PIPE RODDING)

RODDING MACHINE RODDING MACHINE

A machine designed to feed a rod into a pipe while rotating the rod. See PIPE RODDING.

RODDING TOOLS RODDING TOOLS

Special tools attached to the end of a rod or snake to accomplish various results in pipe rodding.

ROOF LEADER ROOF LEADER

A downspout or pipe installed to drain a roof gutter to a storm drain or other means of disposal.

ROOT, SEWER ROOT, SEWER

Any part of a root system of a plant or tree that enters a collection system.

ROOT MOP ROOT MOP

When roots from plant life enter a sewer system, the roots frequently branch to form a growth that resembles a string mop.

ROTAMETER (ROW-ta-meter) ROTAMETER

A device used to measure the flow rate of gases and liquids. The gas or liquid being measured flows vertically up a calibrated tube. Inside the tube is a small ball or a bullet-shaped float (it may rotate) that rises or falls depending on the flow rate. The flow rate may be read on a scale behind the middle of the ball or the top of the float.

ROUGHNESS COEFFICIENT ROUGHNESS COEFFICIENT

A value used in Manning's formula to determine energy losses of flowing water due to pipe or channel wall roughness. Also see FRICTION LOSS, "N" FACTOR and MANNING'S FORMULA.

ROUGHNESS FACTOR ROUGHNESS FACTOR

(See ROUGHNESS COEFFICIENT)

RUNOFF RUNOFF

That part of rain or other precipitation that runs off the surface of a drainage area and does not enter the soil or the sewer system as inflow.

S

SSES SSES

Sewer **S**ystem **E**valuation **S**urvey.

SADDLE SADDLE

A fitting mounted on a pipe for attaching a new connection. This device makes a tight seal against the main pipe by use of a clamp, adhesive, or gasket and prevents the service pipe from protruding into the main.

SADDLE CONNECTION SADDLE CONNECTION

A building service connection made to a sewer main with a device called a saddle.

SAND TRAP SAND TRAP

A device which can be placed in the outlet of a manhole to cause a settling pond to develop in the manhole invert, thus trapping sand, rocks and similar debris heavier than water. Also may be installed in outlets from car wash areas. Also see GRIT CATCHER.

SANITARY COLLECTION SYSTEM SANITARY COLLECTION SYSTEM

The pipe system for collecting and carrying liquid and liquid-carried wastes from domestic sources to a wastewater treatment plant. Also see WASTEWATER COLLECTION SYSTEM.

SANITARY SEWER SANITARY SEWER

A sewer that carries water and water-carried wastes from residences, commercial buildings, industrial plants, and institutions, together with minor quantities of ground, storm, and surface waters (that are not admitted intentionally) to treatment or disposal facilities.

SATURATED SOIL SATURATED SOIL

Soil that cannot absorb any more liquid. The interstices or void spaces in the soil are filled with water to the point at which runoff occurs.

SCALE SCALE

A combination of mineral salts and bacterial accumulation that sticks to the inside of a collection pipe under certain conditions. Scale, in extreme growth circumstances, creates additional friction loss to the flow of water. Scale may also accumulate on surfaces other than pipes.

SCOOTER SCOOTER

A sewer-cleaning tool whose cleansing action depends on the development of high water velocity around the outside edge of a circular shield. The metal shield is rimmed with a rubber coating and is attached to a framework on wheels (like a child's scooter). The angle of the shield is controlled by a chain-spring system which regulates the head of water behind the scooter and thus, the cleansing velocity of the water flowing around the shield.

SCUM SCUM

(1) A layer or film of foreign matter (such as grease, oil) that has risen to the surface of water or wastewater.

(2) A residue deposited on the ledge of a sewer, channel, or wet well at the water surface.

(3) A mass of solid matter that floats on the surface.

SEAL SEAL

(See PIPE JOINT SEAL)

SEALING SEALING

(See CHEMICAL GROUTING)

SEASONAL WATER TABLE SEASONAL WATER TABLE

A groundwater table that has seasonal changes in depth or elevation.

SEDIMENT SEDIMENT

Solid material settled from suspension in a liquid.

SEDIMENTATION (SED-i-men-TAY-shun) SEDIMENTATION

The process of settling and depositing suspended matter carried by wastewater, by gravity. Sedimentation usually occurs when the velocity of the wastewater is reduced below the point at which it can transport the suspended material.

SEISMIC (SIZE-mick) SEISMIC

Relating to an earthquake or violent earth vibration such as an explosion.

SELECT BACKFILL SELECT BACKFILL

Material used in backfilling of an excavation, selected for desirable compaction or other characteristics.

SEPTIC (SEP-tick) SEPTIC

This condition is produced by anaerobic bacteria. If severe, the wastewater turns black, gives off foul odors, contains little or no dissolved oxygen, and creates a high oxygen demand.

SEPTIC TANK SEPTIC TANK

A settling tank in which settled sludge is in intimate contact with the wastewater flowing through the tank and the organic solids are decomposed by anaerobic bacterial action.

SERVICE SERVICE

Any individual person, group of persons, thing, or groups of things served with water through a single pipe, gate, valve, or similar means of transfer from a main distribution system. Also see BUILDING SERVICE.

SERVICE CONNECTION SERVICE CONNECTION

(See BUILDING SEWER)

SERVICE ROOT SERVICE ROOT

A root entering the sewer system in a service line and growing down the pipe and into the sewer main.

SEWAGE SEWAGE

The used water and water-carried solids from homes that flow in sewers to a treatment plant. The preferred term is WASTEWATER.

SEWER SEWER

A pipe or conduit that carries wastewater or drainage water. The term "collection line" is often used also.

SEWER BALL SEWER BALL

A spirally grooved inflatable semi-hard rubber ball designed for hydraulic cleaning of sewer pipes. See BALLING.

SEWER CLEANOUT SEWER CLEANOUT

A capped opening in a sewer main that allows access to the pipes for rodding and cleaning. Usually such cleanouts are located at terminal pipe ends or beyond terminal manholes. Also called a FLUSHER BRANCH.

SEWER GAS SEWER GAS

(1) Gas in collection lines (sewers) that results from the decomposition of organic matter in the wastewater. When testing for gases found in sewers, test for lack of oxygen and also for explosive and toxic gases.

(2) Any gas present in the wastewater collection system, even though it is from such sources as gas mains, gasoline, and cleaning fluid.

SEWER JACK SEWER JACK

A device placed in manholes which supports a yoke or pulley that keeps wires or cables from rubbing against the inlet or outlet of a sewer.

SEWER MAIN SEWER MAIN

A sewer pipe to which building laterals are connected. Also called a COLLECTION MAIN.

SEWER SYSTEM SEWER SYSTEM

(See COLLECTION SYSTEM)

SEWERAGE SEWERAGE

System of piping with appurtenances for collecting, moving and treating wastewater from source to discharge.

SHEAVE (SHE-v) SHEAVE

V-belt drive pulley which is commonly made of cast iron or steel.

SHEETING SHEETING

Solid material, such as wooden sheets or metal plates, used to hold back soil and prevent cave-ins.

SHIELD SHIELD

(1) A fabricated protective crib made of steel or aluminum plate. The shield is placed on the bottom of open trenches in unstable soil areas where conventional protective shoring is not sufficient. From inside the shield, workers can safely install or repair pipelines.

(2) A device used to protect workers from sources of electrical, mechanical, or heat energy.

SHIM SHIM

Thin metal sheets which are inserted between two surfaces to align or space the surfaces correctly. Shims can be used anywhere a spacer is needed. Usually shims are 0.001 to 0.020 inches thick.

SHORING SHORING

Material such as boards, planks or plates and hydraulic jacks used to hold back soil around trenches and to protect workers in a trench from cave-ins. Also see SHEETING.

SILTING SILTING

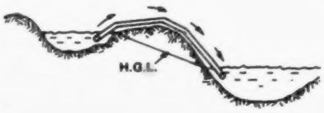
Silting takes place when the pressure of infiltrating waters is great enough to carry silt, sand and other small particles from the soil into the sewer system. Where lower velocities are present in the sewer pipes, settling of these materials results in silting of the sewer system.

SINK SINK

(See DIP)

SIPHON SIPHON

A pipe or conduit through which water will flow above the hydraulic grade line (H.G.L.) under certain conditions. Water (or other liquid) is first forced to flow or is sucked through the pipe by creation of a vacuum. As long as no air enters the pipe to interrupt flow, atmospheric pressure on the liquid at the elevated (higher) end of the siphon will cause the flow to continue.



543

SLEEVE SLEEVE

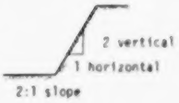
(1) A pipe fitting for joining two pipes of the same nominal diameter in a straight line.

(2) A tube into which a pipe is inserted.

(3) A device to protect a shaft at its bearing or wear points.

SLOPE SLOPE

The slope or inclination of a sewer trench excavation is the ratio of the vertical distance to the horizontal distance or "rise over run." See GRADE (2).



SLUDGE (sluj) SLUDGE

The settleable solids separated from liquids during processing or the deposits of foreign materials on the bottoms and edges of wastewater collection lines and appurtenances.

SMOKE TEST SMOKE TEST

A method of blowing smoke into a closed-off section of a sewer system to locate sources of surface inflow.

SNAKE SNAKE

A stiff but flexible cable that is inserted into sewers to clear stoppages.

SOAP CAKE OR SOAP BUILDUP SOAP CAKE OR SOAP BUILDUP

A combination of detergents and greases that accumulate in sewer systems and build up over a period of time to cause severe restrictions.

SOIL DISPLACEMENT SOIL DISPLACEMENT

Movement of soil from one place to another. Generally accompanies SILTING of a sewer system. Where infiltration is taking place and silt is carried into a sewer system, such silt or soil is removed from the ground around the sewer pipe and the result is soil displacement.

SOIL PIPE SOIL PIPE

(1) A type of wastewater or service connection pipe made of a low grade of cast iron.

(2) In plumbing, a pipe that conveys the discharge of toilets or similar fixtures, with or without the discharges from other fixtures.

SOIL POLLUTION SOIL POLLUTION

The leakage (exfiltration) of raw wastewater into the soil or ground area around a sewer pipe.

SOIL STABILIZATION SOIL STABILIZATION

Injection of chemical grouts into saturated or otherwise unstable soil. The process seals out water and prevents further instability.

SOUNDING ROD SOUNDING ROD

A T-shaped tool or shaft that is pushed or driven down through the soil to locate underground pipes and utility conduits. Also see PROBE.

SPECIFIC GRAVITY SPECIFIC GRAVITY

Weight of a particle or substance in relation to the weight of an equal volume of water. Water has a specific gravity of 1.000 at 40°C (or 39°F). Wastewater particles or substances usually have a specific gravity of 0.5 to 2.5.

SPHERULITIC (SFEAR-you-LIT-tick) SPHERULITIC

A rounded aggregate of particles; or, crystals in the form of a ball.

SPOIL SPOIL

Excavated material such as soil from the trench of a sewer.

SPRINGLINE SPRINGLINE

Theoretical center of a pipeline; or, the guideline for laying a course of bricks.

STABILIZE STABILIZE

To convert to a form that resists change. Organic material is stabilized by bacteria which convert the material to gases and other relatively inert substances. Stabilized organic material generally will not give off obnoxious odors.

STATIC HEAD STATIC HEAD

When water is not moving, the vertical distance (in feet) from a point to the water surface is the static head. Also see DYNAMIC HEAD.

STATION STATION

A point of reference or location in a pipeline is sometimes called a "station." As an example, a building service located fifty-one feet downstream from a manhole could be reported to be at "station fifty-one."

STATION, LIFT STATION, LIFT

(See LIFT STATION)

STILLING WELL STILLING WELL

A pipe, chamber, or compartment with a relatively small inlet or inlets connected to a main body of water, such as water in a wet well. The purpose of a stilling well is to dampen waves or surges while allowing the water level within the well to rise and fall with the major fluctuations of the main body of water. Stilling wells are used with water flow- and depth-measuring devices to improve the accuracy of measurement.

STOPPAGE STOPPAGE

(1) Partial or complete interruption of flow as a result of some obstruction in a sewer.

(2) When a sewer system becomes plugged and the flow backs up, it is said to have a "stoppage." Also see BLOCKAGE.

STORM COLLECTION SYSTEM STORM COLLECTION SYSTEM

A system of gutters, catch basins, yard drains, culverts and pipes for the purpose of conducting storm waters from an area, but intended to exclude domestic and industrial wastes.

STORM RUNOFF STORM RUNOFF

The amount of runoff that reaches the point of measurement within a relatively short period of time after the occurrence of a storm or other form of precipitation. Also called "direct runnoff."

STORM SEWER STORM SEWER

A sewer that carries storm water and surface water, street wash and other wash waters, or drainage, but excludes domestic wastewater and industrial wastes. Also called "storm drain."

STORM WATER STORM WATER

The excess water running off from the surface of a drainage area during and immediately after a period of rain. See STORM RUNOFF.

STORM WATER INLET STORM WATER INLET

A device that admits surface waters to the storm water drainage system. Also see CURB INLET and CATCH BASIN.

STRETCH STRETCH

Length of sewer from manhole to manhole.

STRINGERS STRINGERS

Horizontal shoring members, usually square, rough cut timber, that are used to hold solid sheeting, braces or vertical shoring members in place. Also called WALERS.

STRUCTURAL DEFECT STRUCTURAL DEFECT

A flow or imperfection of a structure or design which was built into a project, pipeline or other collection system appurtenance.

STRUCTURAL FAILURE STRUCTURAL FAILURE

A condition that exists when one or more components of a system break down or fail to perform as expected. A structural failure may result from defective parts or design or may result from other circumstances that occur after the completion of construction.

SUBSOIL GEOLOGY SUBSOIL GEOLOGY

The study of soil conditions existing below the surface of the ground at any selected site.

SUBSYSTEM SUBSYSTEM

An extensive underground sewer system connected to the main collection system, but not considered part of the main system. An example might be the underground sewer system of a mobile home park.

SUCKER RODS SUCKER RODS

Rigid, coupled sewer rods of metal or wood used for clearing stoppages. Usually available in 3 ft, 39 in, 4 ft, 5 ft and 6 ft lengths.

SUCTION HEAD SUCTION HEAD

The *POSITIVE* pressure (in feet or pounds per square inch (psi)) on the suction side of a pump. The pressure can be measured from the center line of the pump *UP TO* the elevation of the hydraulic grade line on the suction side of the pump.

SUCTION LIFT SUCTION LIFT

The *NEGATIVE* pressure (in feet or inches of mercury vacuum) on the suction side of a pump. The pressure can be measured from the center line of the pump *DOWN TO* the elevation of the hydraulic grade line on the suction side of the pump.

SURCHARGE SURCHARGE

Sewers are surcharged when the supply of water to be carried is greater than the capacity of pipes to carry the flow. The surface of the wastewater in manholes rises above the top of the sewer pipe, and the sewer is under pressure or a head, rather than at atmospheric pressure.

SURCHARGED MANHOLE SURCHARGED MANHOLE

A manhole in which the rate of the water entering is greater than the capacity of the outlet under gravity flow conditions. When the water in the manhole rises above the top of the outlet pipe, the manhole is said to be "surcharged."

SURFACE RUNOFF SURFACE RUNOFF

(1) The precipitation that is unable to be absorbed by the soil and flows across the surface by gravity.

(2) The water that reaches a stream by traveling over the soil surface or falls directly into the stream channels, including not only the large permanent streams but also the tiny rills and rivulets.

(3) Water that remains after infiltration, interception, and surface storage have been deducted from total precipitation.

SURFACED DEFECT SURFACED DEFECT

A break or opening in a sewer pipe where the covering soil has been washed away and the opening or break is exposed on the ground surface.

SURFACED VOID SURFACED VOID

A dip or depression in the ground that appears when silting has taken place to a degree that a void is caused in the subsoil and through successive cave-ins, the void reaches the surface of the ground.

SURVEILLANCE TELEVISION EQUIPMENT SURVEILLANCE TELEVISION EQUIPMENT

Economical closed-circuit television equipment designed for surveillance or security work in commercial facilities. Picture resolutions generally range from 250 to 350 lines.

SUSPENDED SOLIDS SUSPENDED SOLIDS

Solid particles that either float on the surface of, or are in suspension in water, wastewater or other liquids. Suspended solids are largely removable by laboratory filtering.

T

TV Log TV Log

A written record of internal conditions during a sewer line TV inspection.

TAG LINE TAG LINE

A line, rope or cable that follows equipment through a sewer so that equipment can be pulled back out if it encounters an obstruction or becomes stuck. Equipment is pulled forward with a pull line.

TAP TAP

A small hole in a sewer where a wastewater service line from a building is connected (tapped) into a lateral or branch sewer.

TELEMETERING EQUIPMENT TELEMETERING EQUIPMENT

Equipment that translates physical measurements into electrical impulses that are transmitted to dials or recorders.

TELEMETRY TELEMETRY

The practice of transmitting and receiving a metered variable.

TELEVISION INSPECTION TELEVISION INSPECTION

An inspection of the inside of a sewer pipe made by pulling a closed-circuit television camera through the pipe.

TELEVISION INSPECTION LOG TELEVISION INSPECTION LOG

A record of a pipeline television inspection which provides date, line location, footage distances, pipe quadrant locations and descriptions of all conditions observed in the inspection. When this log is written, it is called a "written recording." When it is voice recorded on a tape, it is called a "voice tape recording." If the picture is recorded with a video tape recorder with audio remarks, it is called a "video-voice inspection record." Where data-viewing reporting is used, it is called a VIDEO LOG.

TELEVISION MONITOR TELEVISION MONITOR

The television set or kinescope where the picture is viewed on a closed-circuit system.

TEMPORARY GROUNDWATER TABLE TEMPORARY GROUNDWATER TABLE

(1) During and for a period following heavy rainfall or snow melt, the soil is saturated at elevations above the normal, stabilized or seasonal groundwater table, often from the surface of the soil downward. This is referred to as a temporary condition and thus is a temporary groundwater table.

(2) When a collection system serves agricultural areas in its vicinity, irrigation of these areas can cause a temporary rise in the elevation of the groundwater table.

TERMINAL CLEANOUT TERMINAL CLEANOUT

When a manhole is not provided at the upstream end of a sewer main, a cleanout is usually provided. This is called a "terminal cleanout" or a FLUSHER BRANCH.

TERMINAL MANHOLE TERMINAL MANHOLE

A manhole located at the upstream end of a sewer and having no inlet pipe. Also called a DEADEND MANHOLE.

TEST BORE TEST BORE

A hole or bore made to sample and determine the structure of underground soil conditions.

TIDE GATE TIDE GATE

A gate with a flap suspended from a free-swinging horizontal hinge, usually placed at the end of a conduit discharging into a body of water having a fluctuating surface elevation. The gate is usually closed because of outside water pressure, but will open when the water head inside the pipe is great enough to overcome the outside pressure, the weight of the flap, and the friction of the hinge. Also called a BACKWATER GATE.

TOPOGRAPHIC GEOLOGY (TOP-o-GRAPH-ick) TOPOGRAPHIC GEOLOGY

A study of the rock and soil formations of an area for purposes of mapping underground conditions with identifications and elevations. Often called a "geological survey."

TOPOGRAPHY (toe-POG-gra-fee) TOPOGRAPHY

The description or features of an area, such as the hills, valleys, mountains and slope of the land surfaces.

TOTAL CONTRIBUTION TOTAL CONTRIBUTION

All water and wastewater entering a sewer system from a specific facility, subsystem or area. This includes domestic and industrial wastewaters, inflow and filtration reaching the main collection system.

TOTAL FLOW TOTAL FLOW

The total flow passing a selected point of measurement in the collection system during a specified period of time.

TOTAL DYNAMIC HEAD (T.D.H.) TOTAL DYNAMIC HEAD

When a pump is lifting or pumping water, the vertical distance (in feet) from the elevation of the energy grade line on the suction side of the pump to the elevation of the energy grade line on the discharge side of the pump.

TOTALIZER TOTALIZER

A device that continuously sums or adds the flow past the flow meter in gallons or million gallons or some other unit of measurement. Also called an "integrator."

TRAP TRAP

(1) In the wastewater collection system of a building, plumbing codes require every drain connection from an appliance or fixture to have a trap. The trap in this case is a gooseneck that holds water to prevent vapors or gases in a collection system from entering the building.

(2) Various other types of special traps are used in collection systems such as GRIT TRAP or SAND TRAP.

TRAP, DIP TRAP, DIP

(See DIP)

TRAP, HANDHOLE TRAP, HANDHOLE

(See HANDHOLE TRAP)

TRENCH JACK TRENCH JACK

Mechanical screw device used to hold shoring in place.

TRUNK SEWER TRUNK SEWER

A sewer that receives many tributary branches and serves a large territory. See MAIN SEWER.

TRUNK SYSTEM TRUNK SYSTEM

A system of major sewers serving as transporting lines and not as local or lateral sewers.

TURBID TURBID

Having a cloudy or muddy appearance.

TURBIDITY UNITS TURBIDITY UNITS

Turbidity units are a measure of cloudiness of water. Turbidity units, if measured by a nephelometric (reflected light) instrumental procedure, are expressed in nephelometric turbidity units (NTU). Those turbidity units obtained by other instrumental methods or visual methods are expressed in Jackson Turbidity Units (JTU) and sometimes as Formazin Turbidity Units (FTU). The FTU nomenclature comes from the Formazin polymer used to prepare the turbidity standards for instrument calibration.

TWO-WAY CLEANOUT TWO-WAY CLEANOUT

An opening in pipes or sewers designed for rodding or working a snake into the pipe in either direction. Two-way cleanouts are most often found in building lateral pipes at or near to a property line.

U

U-TUBE U-TUBE

(1) A pipe shaped like a U that is constructed in a force main to raise the dissolved oxygen concentration in the wastewater.

(2) U-tube manometers are used to indicate the pressure of a gas or liquid in a confined space.

UNDERMINED UNDERMINED

(1) A condition that occurs when the bedding support under a pipe or manhole has been removed or washed away. Conditions leading to or causing this are believed to be the presence of excess water during backfill. Other causes are horizontal boring operations, excavations adjacent to the pipe or manhole and exfiltration or infiltration at drop joints.

(2) When flow through a broken section of pipe carries away soil around the break leaving a void or empty space, the surfaces over the void are said to be "undermined."

UNDISTURBED SOIL UNDISTURBED SOIL

Soil, at any depth, which has not been excavated or disturbed by excavation or construction.

UPRIGHTS UPRIGHTS

Vertical shoring members that may be solid (SHEETING) or spaced from 2 to 8 feet apart to prevent cave-ins.

UPSTREAM UPSTREAM

The direction against the flow of water; or, toward or in the higher part of a sewer or collection system.

V

V-NOTCH WEIR V-NOTCH WEIR

A triangular weir with a "V" notch calibrated in gallons per minute readings. By holding the weir in a pipe with rubber seals forcing a flow to pass through the "V", a measure of the gallonage flowing through the pipe can be read on the basis of the depth of water flowing over the weir.

VAC-ALL VAC-ALL

Equipment that removes solids from a manhole as they enter the manhole from a hydraulic cleaning operation. Most of the wastewater removed from the manhole by the operation is separated from the solids and returned to the sewer.

VEGETABLE WASTES VEGETABLE WASTES

Vegetable matter entering a collection system. This term is usually used to distinguish such types of waste from animal, industrial, commercial and other types of waste solids.

VEHICLE, LIQUID VEHICLE, LIQUID

(See LIQUID VEHICLE)

VELOCITY HEAD VELOCITY HEAD

A vertical height (in feet) equal to the square of the velocity of flowing water divided by twice the acceleration due to gravity ($V^2/2g$).

VENTS, MANHOLE VENTS, MANHOLE

(See MANHOLE VENTS)

VENTS, WASTELINE SYSTEM VENTS, WASTELINE SYSTEM

(See WASTELINE VENT)

VERTICAL OFFSET VERTICAL OFFSET

A pipe joint in which one section is connected to another at a different elevation, such as a DROP JOINT.

VIDEO INSPECTION VIDEO INSPECTION

A television inspection.

VIDEO LOG VIDEO LOG

A magnetic tape picture recording of a television inspection where data-view reporting has been included as part of the visual record. Also see DATA-VIEW.

VIDEO TAPE VIDEO TAPE

A magnetic tape for recording television pictures. Standard tapes also have a capacity to record a voice with the picture, or an "audio" accompaniment.

VOID VOID

A pore or open space in rock or granular material that is not occupied by solid matter. It may be occupied by air, water, or other gaseous or liquid material. Also called "interstice" or "void space."

VOLTAGE VOLTAGE

The electrical pressure available to cause a flow of current (amperage) when an electrical circuit is closed. See ELECTROMOTIVE FORCE (E.M.F.)

VOLUTE (vol-LOOT) VOLUTE

The spiral-shaped casing surrounding a pump impeller that collects the water discharged by the impeller.

W

WALERS (WAY-lers) WALERS

Horizontal shoring members, usually square, rough cut timber, that are used to hold solid sheeting, braces or vertical shoring members in place. Also called STRINGERS.

WARNING WARNING

This word emphasizes that hazardous voltages, currents and temperatures could cause personal injury or damage to equipment.

WASTELINE CLEANING WASTELINE CLEANING

An opening or point of access in a building wastewater pipe system for rodding or snake operation.

WASTELINE SYSTEM WASTELINE SYSTEM

(See BUILDING WASTEWATER COLLECTION SYSTEM)

WASTELINE TRAP WASTELINE TRAP

(See TRAP (1))

WASTELINE VENT WASTELINE VENT

Most plumbing codes require a vent pipe connection of adequate size and located downstream of a trap in a building wastewater system. This vent prevents the accumulation of gases or odors and is usually piped through the roof and out of doors.

WASTEWATER WASTEWATER

The used water and water-carried solids from a community that flow to a treatment plant. Storm water, surface water, and groundwater infiltation also must be included in the wastewater that enters a plant. The term "sewage" usually refers to household wastes, but this word is being replaced by the term "wastewater."

WASTEWATER COLLECTION SYSTEM WASTEWATER COLLECTION SYSTEM

The pipe system for collecting and carrying water and water-carried wastes from domestic and industrial sources to a wastewater treatment plant.

WASTEWATER FACILITIES WASTEWATER FACILITIES

The pipes, conduits, structures, equipment, and processes required to collect, transport, and treat domestic and industrial wastes, and dispose of the effluent.

WASTEWATER TREATMENT PLANT WASTEWATER TREATMENT PLANT

(1) An arrangement of pipes, equipment, devices, tanks and structures for treating wastewater, industrial wastes, and sludge.

(2) A water pollution control plant.

WATER HAMMER WATER HAMMER

The sound like someone hammering on a pipe that occurs when a valve is opened or closed very rapidly. When a valve position is changed quickly, the water pressure in a pipe will increase and decrease back and forth very quickly. This rise and fall in pressures can cause serious damage to the system.

WATER TABLE WATER TABLE

The upper surface of the portion of the ground wholly saturated with water.

WATER TABLE DEPTH WATER TABLE DEPTH

(See GROUNDWATER DEPTH)

WATER TABLE ELEVATION WATER TABLE ELEVATION

(See GROUNDWATER ELEVATION)

WATER TABLE HEAD WATER TABLE HEAD

(See PRESSURE HEAD)

WAYNE BALL WAYNE BALL

A spirally grooved, inflatable, semi-hard rubber ball designed for hydraulic cleaning of sewer pipes. See BALLING and SEWER BALL.

WEIR (Weer) WEIR

(1) A wall or plate placed in an open channel and used to measure the flow. The depth of flow over the weir can be used to calculate the flow rate, or a chart or conversion table may be used. (2) A wall or obstruction used to control flow (from clarifiers) to assure uniform flow and avoid short-circuiting.

WELL POINT WELL POINT

A hollow, pointed rod with a perforated (containing many small holes) tip. A well point is driven into an excavation where water seeps into the tip and is pumped out of the area. Used to lower the water table and reduce flooding during an excavation.

WET PIT WET PIT

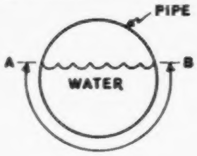
(See WET WELL)

WET WELL WET WELL

A compartment or room in which wastewater is collected, and to which the suction pipe of a pump may be connected. Also, a submersible pump may be located in a wet well.

WETTED PERIMETER WETTED PERIMETER

The length of the wetted portion of a pipe covered by flowing wastewater.



Wetted Perimeter = Distance from A to B

WICK EFFECT WICK EFFECT

(See CAPILLARY EFFECT)

Y

"Y" CONNECTION "Y" CONNECTION

Another name for a BUILDING SERVICE.

Z

ZONE OF SATURATION ZONE OF SATURATION

(1) Where raw wastewater is exfiltrating from a sewer pipe, the area of soil that is moistened around the leak point is often called the "zone of saturation."

(2) The area of soil saturated with water.

OPERATION AND MAINTENANCE OF WASTEWATER COLLECTION SYSTEMS

VOLUME II

SUBJECT INDEX

A

AIDS, 300
Accident investigations, 337
Accident report, 309, 310
Accidents, 299, 303
Accountability, 410
Accounting, cost, 375
Administration
  accident investigations, 337
  benefits, 333
  certification, 334, 335
  compensation, 333
  computers, 364
  contract equipment, 339, 340
  contracts, employee, 335
  controlling, 384-386
  coordinates, maps, 354
  corporation yard, 348
  data processing, 364
  design, 351
  directives, 386
  effective, 321
  employee relations, 335
  employment, 328
  equipment, 338-346, 349
  facilities, 348
  goals, 322
  grievances, 336
  inventory, 347
  investigations, accident, 337
  landscaping, 351
  lease, purchase or contract, 339, 340
  maintenance, 347, 362
  management, 347
  management information systems, 363-389
  mapping, 352-362
  microcomputers, 364
  microfiche, 362
  mission statement, 322
  need, 321
  negotiations, 335
  objectives, 332
  offices, 350
  operating plan, 321
  operators' facilities, 349
  parking, 351
  personnel, 325
  plan, 321
  planning, 384-386
  policy statement, safety, 336
  principles, 321
  procedures, 322
  public relations, 392-394
  purchase, equipment, 339, 340
  records, 375-383
  repair, 347
  replacement, 347
  report writing, 390
  responsibilities, safety, 337
  safety, 306, 336, 337, 344
  salaries, 333
  security, 349
  shop, 349
  software, 364
  tasks, 322
  tools, 338-346
  training, 334, 337, 348
  vehicles, 340
  work directives, 386
  work reports, 366-375
  writing reports, 390
  yard, maintenance, 348
Air bubblers, 38, 40-42
Air compressors, 222-224
Air release valve, 19-21
Alarms, lift station, 74-76, 79-81
Alignment
  motors, 147, 150
  pumps, 216, 218
Alternating current, 131
Ammeter, 134
Ammonia, 301
Amps, 131
Anaerobic decomposition, 301
Ancillary facilities, 350
Annular space, 281
Area maps, 354
Assignment of personnel, 412-419
Atmospheric testers, 344
Authority, 409, 411
Auxiliary equipment, lift station, 59
Awareness, safety, 298

B

Bar racks, 27
Base maps, 354
Bearings, pump, 44, 197-215
Belts, pump, 218-220
Benefits
  compensation, 333
  safety, 303-306
Bites, 302
Block maps, 356, 359
Blowers, 345
Brinelling, 197, 200, 201
Budgeting, 375

C

Carbon monoxide, 301
Cast-in-place lift stations, 9, 15-17
Cavitation, 24, 168
Centrifugal pumps, 42-56, 169-172, 180

Certification, 334, 335
Check valves, 59, 61
Chemical grouting, 262, 263
Chlorinator maintenance, 106-109
Chlorine, 301
Christy box, 286
Circuit breakers, 136, 138
Claim defense, 376
Collection system organization, 442-444
Commitment, safety, 298, 307
Committee, safety, 308
Compensation, 333
Compressors, 222-224
Computer controls, 74-76
Computers, 364
Conductors, 132
Confined space
  policy, 308
  safety requirements, 445
Construction
  lift station, 63
  problems, 257
Contacts, starters, 147-150
Contract equipment, 339, 340
Contracts
  employee, 335, 336
  union, 335, 336
Controlling, 384-386, 411
Controls
  air bubblers, 38, 40-42
  computer, 74-76
  electrodes, 38, 39
  float, 35-38
  lift station, 28, 31, 34
  microprocessor, 42, 43
  seal trode, 38, 39
  supervisory, 31, 34, 42
Contusions, 300
Coordinates, maps, 354
Corporation yard, 384
Cost accounting, 375
Cost-effectiveness, rehabilitation, 257, 258
Coupling maintenance, 110, 216-220
Crews, organization, 412
Current, electrical, 131
Curve, pump, 54-56

D

Danger, 299
Data collection, sewer rehabilitation, 255
Data processing, 364
Debris severity, 449
Defense claim, 376
Design, 351
Diaphragm pump, 182, 184
Direct current, 131
Direct time, maintenance, 326-328
Directing, 411
Directives, work, 386
Disconnect main, 28
Disconnect switch, 135, 136
Diseases, 299
Dispatcher, 444
Dispatcher's record, 79, 80
Drowning, 302
Dry wells, 9, 28
Dye-water flooding, 253
Dynamic head, 19, 22, 24

E

Eccentric valve, 59-61
Economics, safety, 303-306
Effectiveness, 450, 451
Electrical equipment maintenance, 129-139
Electrical motors, 111-113, 140-159
Electrical system
  control, 139
  lift station, 28-31
  starters, 146-149
  switch gear, 135
  wet well, 27
Electricity
  circuit breakers, 136, 138
  circuits, 132-134
  fuses, 136, 137
  meters, 132, 133
  safety, 302
  starters, 146-149
  terms, 131
  testers, 132, 133
  tools, 132, 133
Electrode controllers, 38, 39
Emergency
  maintenance, 446
  service, 412
  truck, 340
Employee
  orientation, 332, 333
  relations, 335
  selection, 332
Employment, 328
Energy consumption, lift station, 8
Energy grade line, 23
Equality of service, 393
Equipment, 338-346, 349
Equipment servicing, 435-438
Excavate and replace, rehabilitation, 257-262
Excavation, 302
Explosions, 300
Eye protection policy, 309

F

Facilities, 348
Factory assembled lift station, 9, 14
Failure consequences, rehabilitation, 256
Failure matrix, rehab, 256
Failure, motors, 143
Falling objects, 299
Falls, 300
Fayol, Henri, 321
Fire, 302
Float controllers, 35-38
Flow, lift station, 19
Force main, 8, 19, 21, 87
Fuses, 136, 137

G

Gases, 301
Gate valves, 56-59
Gear drive, right angle, 66, 67
Goals, 322
Greasing, 226
Grid coordinate system, 354, 355
Grievances, 336
Ground, 139
Grouting, 262

H

Hansen Software, Inc., 364, 382-389
Hard hat policy, 309
Head
  dynamic, 19, 22, 24
  lift station, 19, 22-24
  static, 19, 23, 24
Hydraulic aspects, rehabilitation, 245-253
Hydraulic grade line, 23
Hydrogen sulfide, 301
Hygienic facilities, 349

I

Imbalance, voltage, 145
Impeller, 27, 54, 186-189
Infections and infectious diseases, 299
Indirect time maintenance, 326-328
Industrial waste inspections, 414, 440
Infiltration/inflow, 438
Injuries, 303
Insituform, 263-278
Inspection
  frequency, 72
  lift station, 65-70
  lubrication, 226
  organization, 414, 438-441
  sewers, 240, 243
Insulation
  materials, 144
  motors, 143
Insulators, 132
Inventory, 347, 353
Inversion, 263
Investigations
  accident, 337
  organization, 414, 438-441

J

Job steward, 335, 336
Jogging, 154

K

NO LISTINGS

L

Lacerations, 300
Landscaping, 351
Lease, purchase or contract, 339, 340
Legal defense, 376
Legend, maps, 360, 361
Let's Build a Pump, 163, 168
Life-cycle costing, 257
Lift station
  alarms, 74-76, 79-81
  appearance, 8
  auxiliary equipment, 59
  bar racks, 27
  calibration, 64, 65
  cast-in-place, 9, 15-17
  components, 25
  computer control, 74-76
  construction, 63
  controls, 28, 31, 34-42, 74-76
  design review, 63
  disconnect, main, 28
  dry wells, 28
  electrical system, 28-31
  energy consumption, 8
  factory assembled, 9, 14
  flow, 19
  head, 19, 22-24
  inspections, 65-70
  location, 8
  main disconnect, 28
  maintenance, 83-85, 95
  metering, 28
  monitoring, 74-76
  motor control center, 28
  motors, 31
  newly constructed, 63
  noise, 8
  odors, 8
  operation, 69-82
  planning, 63
  pneumatic ejector, 9, 18
  power transformers, 28
  prefabricated, 9, 14
  prints, 63
  problems, 82
  pumps, 42-56
  purpose, 8
  recordkeeping, 85-88
  requirements, 19
  safety, 8, 65, 72
  scheduling maintenance, 84-87
  specifications, 63
  sump pump, 56
  supervisory controls, 31, 34
  telemetry, 74-76
  transfer switch, 28
  troubleshooting, 82
  type, 9-18
  valves, 19-21, 56-61
  ventilation, 59
  visits, 72-79
  wet wells, 25-27
Lining, sewers, 278-286
Lock-out policy, 308
Lubricants, 226
Lubrication, 66-68, 84, 111-113, 153, 220, 224-226
Lubriflushing, 84

M

Magnetic starters, 147-149
Main disconnect, 28
Maintenance
  actual schedule, 85
  administration, 347-362
  air bubblers, 40
  air compressor, 105, 222, 223
  chlorinator, 106-109
  couplings, 110
  electrical equipment, 129-139
  electrical motors, 111-113, 140-159
  lift stations, 83-85, 95
  lubrication, 66-68, 224-226
  management, 347
  maps, 362
  mechanical, 414, 435-438
  motors, 111-113, 140-159
  preventive, 413, 422, 437, 446
  pumps, 162-182
  recordkeeping, 85
  scheduling, 84-87, 97, 98, 101-103, 446-451
  sump pumps, 116
  time requirements, 326-328
  valves, 118

Maintenance (continued)
  ventilation blower, 105, 106
  wells, water, 118, 119
  yard, 384
Management, 347
Management information systems
  see pages 363-389
  accountability, 410
  applications, 364
  computers, 364
  controlling, 384
  data processing, 364
  definition, 363
  directives, 386
  microcomputers, 364
  need, 363
  organization, 410
  planning, 384
  records, 375-383
  reports, 366, 384
  software, 364
  work directives, 386
  work reports, 366
Management of Local Public Works, 363
Management, safety, 306
Mandrel, 176
Manhole
  inspection, 438
  rehabilitation, 287, 288
  sealing, 286
  wet well, 9
Manpower requirements, 325, 328
Mapping
  coordinates, 354
  elevations and depths, 353
  examples, 356
  grid coordinate system, 354, 355
  identifications, 352
  importance, 352
  information, 352
  lengths and widths, 353
  maintenance, 362
  management, 347, 352-389
  microfiche, 362
  preparation, 356
  records, 362
  revision, 356
  size, 354
  type, 354
Maps
  area, 354
  base, 354
  block, 356, 359
  legend, 360, 361
  master, 354, 356, 357
  section, 354, 356, 358
  symbols, 360, 361
Master maps, 354, 356, 357
Matrix, failure, rehab, 256
Mechanical
  maintenance, 414, 435-438
  seals, 51, 52, 195-197
Meeting, safety, 308
Megger, 134
Megohm, 134
Metering, 28
Meters, electrical, 132, 133
Microcomputers, 346, 364
Microcomputers in Public Works, 364
Microfiche, 362
Microprocessor, 42, 43
Mission statement, 322
Monitoring lift stations, 74-76
Motor control center, 28, 139
Motor protection devices, 138
Motors
  alignment, 147, 150
  contacts, 147, 150
  electrical, 111-113, 140-159
  failure, 143-146
  induction, 158
  insulation, 143
  lift station, 31
  lubrication, 153
  performance, 151, 152
  records, 159-161
  rotation, 150
  safety, 147
  starters, 146-149
  temperature limits, 144
  troubleshooting, 153-158
  types, 140
  vibrations, 153

N

Nameplate, 129, 140, 142
Negotiations, 335
Noise
  lift station, 8
  safety, 302
Nonclog pumps, 44, 49

O

Objectives, management, 332
Occupational
  description, 328
  titles, 411
Odors, lift station, 8
Offices, 350
Ohmmeter, 134
Ohm's Law, 131
Oiling, 226
Operating plan, 321
Operation
  data, 88
  frequency, 72
  inspection, 69, 70
  lift station, 69-82
  pumps, 182
  records, 88
Operators' facilities, 349
Organization
  accountability, 410
  activities, work, 411
  collection system, 442-444
  crews, 412
  emergency maintenance, 446
  equipment servicing, 435-438
  industrial waste inspections, 440
  infiltration/inflow investigation, 438
  inspection, 438-441
  investigation, 438-441
  maintenance, 422, 435-438, 446-451
  management, 410
  manhole inspections, 438
  mechanical maintenance, 435-438
  need, 409

Organization (continued)
  overall, 442-444
  performance indicators, 452
  personnel, 411
  preventive maintenance, 422, 437, 446
  principles, 409
  reorganization, 446
  repairs, 429-434
  replacement, 429-434
  responsibility, 410
  safety, 445
  scheduling maintenance, 446-451
  service requests, 422-424
  staff, 442
  stoppage removals, 423
  TV inspection, 438
  training crews, 429-431
  work activities, 411
Organizing, 411
Overload protection, 147
Oxygen deficiency, 301

P

Packing, pump, 44, 51, 52, 191-195
Parking, 351
Pathogenic organisms, 299
Payrolls, 375
Performance evaluation, 448, 450
Performance indicators, 452
Personnel, 325, 411-419
Piezometer, 247, 249
Pipe, types, 353
Piston pumps, 176, 178
Plan, operating, 321
Planning, 384, 411
Plant Manager's Handbook, 337
Plug valves, 59-61
Plugs, 342
Pneumatic controllers, 38
Pneumatic ejector, 9, 18, 174-176
Pneumatic pump, 182, 184
Poisonous gases, 301
Pole shader, 154
Policies, safety, 308
Policy, sewer maintenance, 393, 394
Policy statement, safety, 336
Polyethylene pipe lining, 278-286
Portable pump, 180-183
Positive displacement pump, 182, 184
Power
  requirements, 132
  supply, 151, 152
  transformers, 28
Pre-employment inquiries, 330, 331
Prefabricated lift station, 9,14
Pressure-sensing controllers, 38, 40-42
Pretreatment facility, inspection, 440
Preventive maintenance, 413, 422, 437, 446
Principles
  administration, 321
  organization, 409
Prints, lift station, 63
Priority setting, rehabilitation, 256
Problems
  construction, 257
  excavation and replacement, 262
Professional magazines, 334
Professionalism, safety, 299
Program benefits, safety, 303
Promoted, 266
Promotion, 337
Protection devices, motor, 138
Protective clothing, 345
Public relations, 392-394
Pump station
  see Lift station
Pumps
  alignment, 216, 218
  bearings, 44, 197-215
  belts, 218-220
  centrifugal, 42-56, 169-172
  close-coupled, 178
  components, 44
  coupling maintenance, 110, 216, 220
  curve, 54-56
  diaphragm, 182, 184
  impeller, 27, 54, 186-189
  layouts, 44
  Let's Build a Pump, 163-168
  lift station, 42-56
  mechanical seals, 51, 52, 195-197
  nonclog, 44, 49
  packing, 44, 51, 52, 191-195
  piston, 176, 178
  pneumatic ejector, 174-176
  pneumatic, pump, 182, 184
  portable, 180-183
  positive displacement, 182, 184
  records, 159, 160
  screw, 169, 173
  seals, 51, 52
  selection curve, 54-56
  shaft, 44, 189-191, 220, 221
  sleeves, 189-191
  stuffing box, 189
  sump, 56
  troubleshooting, 182, 183
  types, 162, 169
  volute, 54
  uses, 162
  wear rings, 44, 50
Purchase, equipment, 339, 340

Q

Qualification profile, 329
Query retrieval system, 385

R

Recordkeeping
  administration, 375-383
  costs, 85
  dispatcher, 79, 80
  electrical equipment, 159
  filing, 85
  lift station, 85-88
  maintenance, 85
  management, 375-383
  maps, 362
  motors, 159, 161
  operation, 88
  pumps, 160
  safety, 309
  service requests, 386, 387
Rehabilitation, sewer
  chemical grouting, 262
  condition evaluation, 245-253
  costs-effectiveness, 257

Rehabilitation (continued)
  costs, 255
  data collection, 255
  dye-water flooding, 253
  excavate and replace, 257-261
  failure consequences, 256
  failure matrix, 256
  grouting, 262
  hydraulic aspects, 245-253
  Insituform, 263-278
  leaks, 247, 250-253
  lining, 278-286
  manholes, 287
  methods, 257-287
  polyethylene pipe lining, 278-286
  priority setting, 256
  program, 240-245
  service connections, 286
  shotcrete, 263
  smoke testing, 252-253
  structural aspects, 253-255
Reorganization, 446
Repair, 347, 413, 429-434
Replacement, 347, 413, 429-434
Report writing, 390
Responsibilities, safety, 298, 306, 307, 337, 410
Right-angle gear drive, 66, 67
Rotation, motors, 150
Ruptures, 302

S

SSES, 245
Sacramento County, 448
Safety
  AIDS, 300
  accident report, 309, 310
  accidents, 299, 303
  administration, 306, 336, 337, 344
  ammonia, 301
  atmospheric testers, 344
  awareness, 298
  benefits, 303-306
  bites, 302
  blowers,345
  carbon monoxide, 301
  chlorine, 301
  commitment, 298, 307
  committee, 308
  confined space policy, 308
  contusions, 300
  danger, 299
  diseases, 299
  drowning, 302
  economics, 306
  electricity, 126, 129, 302
  equipment, 344
  excavation, 302
  explosions, 300
  eye protection policy, 309
  falling objects, 299
  falls, 300
  fire, 302
  gases, 301
  hard hat policy, 309
  hydrogen sulfide, 301
  infections and infectious diseases, 299
  injuries, 303
  lacerations, 300
  lift stations, 8, 65, 72
  lock-out policy, 308
  management, 306
  meetings, 308
  motors, 147
  noise, 302
  organization, 445
  oxygen deficiency, 301
  poisonous gases, 301
  policies, 308, 309
  professionalism, 299
  program benefits, 303
  protective clothing, 345
  records, 309
  responsibilities, 298, 306, 307
  ruptures, 302
  safety vest policy, 309
  seat belt policy, 309
  shock, electrical, 302
  shoring, 302, 345, 445
  slips, 299
  strains, 302
  survey, 303-305
  tailgate, 307
  toxic gases, 301
  traffic control, 345
  traffic mishaps, 302
  training, 323
  trenches, 302
  typhoid fever, 300
  vest, safety policy, 309
  warning tag, 130
  wet wells, 27
Salaries, 333
Santa Clara County, 448
Scheduling maintenance, 446-451
Screw pump, 169, 173
Seal trode controllers, 38, 39
Seals, pump, 51, 52
Seat belt policy, 309
Section maps, 354, 356, 358
Security, 349
Service connection, rehabilitation, 286
Service request
  organization, 422
  personnel, 413
  reports, 386, 387
Severity, debris, 449
Sewer rehabilitation
  see Rehabilitation, sewer
Sewer system evaluation survey (SSES), 245
Shaft, pump, 44, 189-191, 220, 221
Shim, 216
Shock, electrical, 302
Shop, 349
Shop steward, 335, 336
Shoring, 260, 302, 345, 445
Shotcrete, 263
Sleeves, pump shaft, 189-191
Slips, 299
Smoke testing, 252, 253
Software, 364
Specifications, lift station, 63
Squirrel cage induction motor (SCIM), 31-34, 140, 141
Staff, organization, 442
Starters, 146-150
Static head, 19, 23, 24
Steward, 335, 336
Stoppage removals, 423
Strains, 302

Stretch, 247
Structural aspects, rehabilitation, 253-255
Stuffing box, 189, 190
Submergence, 26
Submersible pump, 9-12, 31, 178, 179
Surcharge, 240
Sump pump, 56, 116
Supervisory controls, 31, 34, 139
Switch gear, electrical, 135
Symbols, map, 360, 361

T

TV inspection, 438
Tailgate safety program, 307
Tasks, 322
Telemetry, lift stations, 74-76
Telephone courtesy, 392, 393
Temperature limits, motors, 144
Testers, electrical, 132
Thermostat, 146
Time for maintenance, 326-328
Tools
  electrical, 132
  requirements, 338-346
Toxic gases, 301
Traffic control, 345, 445
Traffic mishaps, 302
Training, 323, 334, 337, 338, 429-431
Transfer switch, 28
Trash pumps, 180
Trenches, 302
Trends in stoppages, 377
Troubleshooting
  electricity, 126
  lift stations, 82
  motors, 153-158
  pneumatic ejector, 174
  pumps, 182, 183
Trucks, 340, 341
Typhoid fever, 300

U

Unbalance, voltage, 145
Union contract, 335, 336
Unitization, 409

V

Valves
  air release, 19-21
  check, 59, 61
  eccentric, 59-61
  gate, 56-59
  lift station, 56-59
  maintenance, 118
  plug, 59-61
Vehicles, 340, 341
Ventilating
  blower maintenance, 105, 106
  lift stations, 59, 80, 81
Vibration, motors, 153
Visits, lift station, 72-79
Voltage, imbalance, 145
Volts, 131
Volute, 54

W

WPCF safety survey, 303-305
Warning tag, 130
Watts, 132
Wear rings, 44, 50
Wells, water, 118, 119
Wet wells, 9-12, 25-27
Work
  activities, 411-419
  directives, 386
  orders, 388, 389
  reports, 386
Writing reports, 390

Y

Yard, maintenance, 384